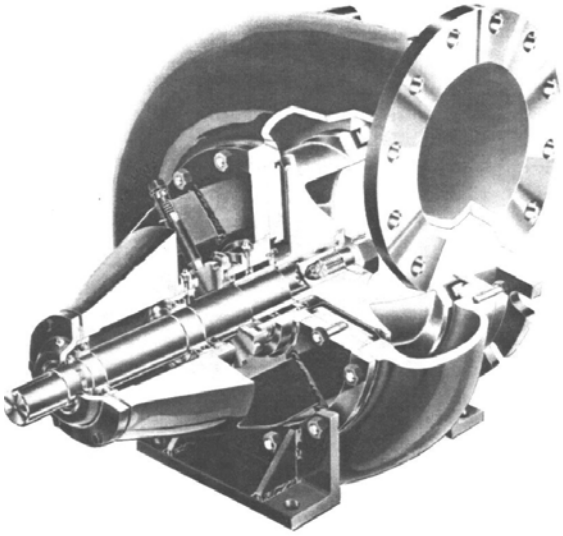
GARDNER DENVER®

TUL-C-600 Rev A
January, 2005

CENTRIFUGAL PUMPS



4” x 5” and 5” x 6”

PARTS LIST
OPERATING AND
SERVICE MANUAL

Gardner Denver

ECN 1024021

MAINTAIN PUMP RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER PARTS AND SUPPORT SERVICES

Gardner Denver® genuine pump parts are manufactured to design tolerances and are developed for optimum dependability. Design and material innovations are the result of years of experience with hundreds of different pump applications. Reliability in materials and quality assurance is incorporated in our genuine replacement parts.

Your authorized Gardner Denver Sales Office offers all the backup you'll need. The Fort Worth Manufacturing Facility maintains a large inventory of genuine parts.

Gardner Denver supports your needs with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. Repair and maintenance kits designed with the necessary parts to simplify servicing your pump.

Authorized service technicians are factory trained and skilled in pump maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

For the location of your local authorized Gardner Denver distributor, refer to the yellow pages of your phone directory or contact:

Gardner Denver
Pump Products
4747 South 83rd East Avenue
Tulsa, Oklahoma 74145

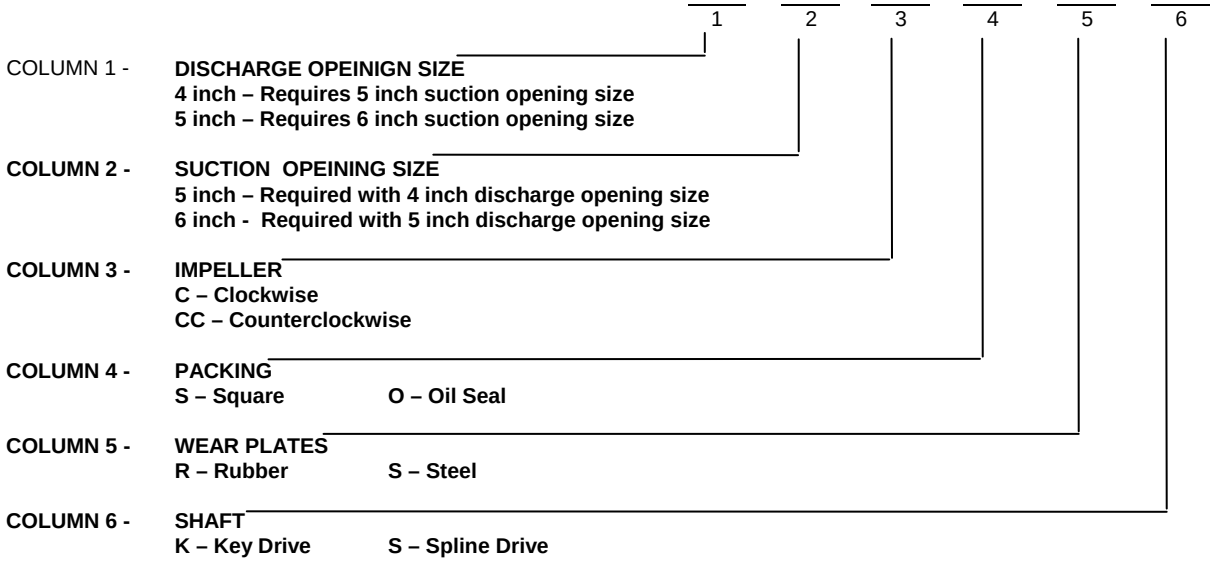
Phone: (918) 664-1151
(800) 637-8099
Fax: (918) 664-6225
Email: sales@gardnerdenvertulsa.com

INSTRUCTIONS FOR ORDERING REPAIR PARTS

All orders for parts should be placed with the nearest authorized distributor and should include the following information:

- The pump model and serial number (see nameplate on the unit.)
- Part number and description of the part.
- Part number and description of the part.
- Specify exactly the number of parts required **(do not order by sets or groups).**
- The name and address of your company
- The name and telephone number of contact person.
- Your purchase order or requisition number.
- Complete shipping address (where the parts are to be shipped.

MODEL MATRIX
ORDER BY MODEL NUMBER FROM NAMEPLATE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2
3
4
5
6
COLUMN 1 - DISCHARGE OPEINIGN SIZE
4 inch – Requires 5 inch suction opening size
5 inch – Requires 6 inch suction opening size
COLUMN 2 - SUCTION OPEINING SIZE
5 inch – Required with 4 inch discharge opening size
6 inch - Required with 5 inch discharge opening size
COLUMN 3 - IMPELLER
C – Clockwise
CC – Counterclockwise
COLUMN 4 - PACKING
S – Square
O – Oil Seal
COLUMN 5 - WEAR PLATES
R – Rubber
S – Steel
COLUMN 6 - SHAFT
K – Key Drive
S – Spline Drive

FOREWORD

Gardner Denver® pumps are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this pump the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance personnel essential information for day-to-day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimal downtime.

Gardner Denver Design Features Give Long Life & Easy Maintenance.

- A light weight, compact, 4”x5” Pump and a medium weight 5”x6” Pump are extremely rugged and require minimal mounting space.
- A heavy steel frame and mounting bracket for horizontal or vertical positioning.
- Every frame is predrilled to accept a direct drive SAE hydraulic motor, in conjunction with an internal splined shaft to eliminate down time due to misalignment. A key driven shaft is also available.
- Segmented construction allows the customer to purchase only those parts necessary for repair.
- Sacrificial front and rear wear plates are provided with every new pump. Rubber coated palates are normally provided, although steel plates are available for exotic mediums such as Zylene and Toluene.
- Change of rotation may be easily accomplished by simply removing, turning, and repositioning the volute and changing the impeller to match the desired direction of rotation.
- The open impellers allow the free movement of large particles and extremely heavy, abrasive laden slurries. Available in either a clockwise or counterclockwise rotation, the impeller is secured to the shaft by a superior designed locking system.
- We offer two packing choices. Solid lip seals provide efficient service and with a minimal amount of attention. Split compression type packing is available for more severe service conditions and can easily be replaced without dismantling the pump.
- Bearing are double row inboard for radial thrusts, and a single row outboard for axial thrusts.

DANGER

Danger is used to indicate the presence of a hazard, which will cause severe personal injury, death or substantial property damage if the warning is ignored.

WARNING

Warning is used to indicate the presence of a hazard, which can cause severe personal injury, death or substantial property damage if the warning is ignored.

CAUTION

Caution is used to indicate the presence of a hazard, which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard related.

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious. Some general safety precautions are given below:

DANGER

Failure to observe these notices could result in injury to or death of personnel.

- **Keep fingers and clothing away from unit inlet and discharge ports, revolving belts, sheaves, drive couplings, etc.**
- **Do not use the air discharge from this unit for breathing – not suitable for human consumption.**
- **Do not loosen or remove the oil filler plug, drain plugs, covers or break any connections, etc., in the unit or oil system until the unit is shut down and all pressure has been relieved.**
- **Electric shock can and may be fatal.**
- **The unit must be grounded in accordance with the National Electrical Code.**
- **Open main disconnect switch, tag and lockout before working on the control.**
- **Disconnect the unit from its power source, tag and lockout before working on the unit – the machine may be automatically controlled and may start at any time.**

WARNING

Failure to observe these notices could result in damage to equipment.

- **Stop the unit if any repairs or adjustments on or around the unit are required.**
- **Do not exceed the rated maximum speed shown on the nameplate.**
- **Do not operate unit if safety devises are not operating properly. Check periodically. Never bypass safety devices.**

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SECTION 1
DANGER NOTICES

DANGER

Read and understand the following DANGER NOTICES before moving or operating the pump or any pump package unit equipment.

Pumps are machines capable of producing high fluid pressures and flow rates and are designed to be used with proper care and caution by trained, experienced operators. **TO AVOID PERSONAL INJURY, DEATH AND/OR EQUIPMENT DAMAGE, READ AND THOROUGHLY UNDERSTAND THE FOLLOWING DANGER NOTICES PLUS THE ENTIRE OPERATING AND SERVICE MANUAL BEFORE ATTEMPTING TO MOVE OR OPERATE THE PUMP. Contact a Gardner Denver service representative, if you are unable to comply with any of the danger notices or procedures described in these documents.**

Closely examine the pump performance data upon pump delivery to become thoroughly familiar with the operating limits for this pump model. **The pump must <u>never</u> be operated at speeds, pressures or horsepower exceeding the maximum values or at speeds below the minimum. Failure to observe the operating limits could result in personal injury, death, and/or equipment damage and will void the warranty.** Alterations to the pump, or application of the pump outside the limits, must not be made without Gardner Denver written approval, together with a new set of performance data, as dangerous operating conditions could result.

THE DANGER NOTICE AND DATA PLATED PROVIDED ON THE EQUIPEMNT MUST NOT BE REMOVED, PAINTED OVER, HIDDEN OR DEFACED. They must be replaced if they become damaged or unreadable. Provisions should be made to have the following written danger notices plus the pump operating and service manual readily available to operators and maintenance personnel. In addition, copies of all pump system accessory component (e.g. hydraulic motor, engine, and electric motor, etc.) Read and follow all the precautions and instructions contained in these manuals. If any of these documents are lost or become illegible they must be replaced immediately. The danger notices plus the operating and service manuals should be reread periodically by both operators and maintenance personnel to refresh their memories in safe procedures and practices.

Keep in mind that full operator attention and alertness are required when operating high pressure pumping equipment. Operators should not begin or continue operations when tired, distracted or under the influence of alcohol or any type of prescription or nonprescription drugs.

The timely replacement of expendable parts and any other worn or damaged parts can prevent equipment damage and possible injury. The original parts used in Gardner Denver pumps are designed and tested to exacting standards to provide high quality performance and durability. Your best insurance in maintaining these characteristics is to use genuine Gardner Denver replacement parts.

A broad range of danger notices are covered on these pages, however, they cannot substitute for training, experience and common sense in the safe operation of high pressure pumping equipment.

COVERS AND GURARDS

DANGER

All moving parts on the entire pump package, including but not limited to engine or motors, drive shafts, belts, chains, pulleys, gears, etc., must be equipped with guards or covers, which must also be securely fastened in proper position at all times when the equipment is operating.

Covers and guards are intend to not only protect against personal injury or death, but to also protect the equipment from damage from foreign objects.

EQUIPMENT MOVING AND LIFTING

DANGER

Heavy equipment including pumps, pump package units and components should only be moved or lifted by trained, experienced operators, who are physically and mentally prepared to devote full attention and alertness to the moving and lifting operations. An operator should be fully aware of the use, capabilities and condition of both the equipment being moved, and the equipment being used to move it.

DANGER

Failure to follow safe and proper pump, pump package or component lifting or moving procedures can lead to personal injury, death and/or equipment damage from shifting, falling or other unexpected or uncontrolled equipment movements.

Make sure the hoist, lift truck, ropes, slings, spreader, or other lifting equipment you are using is in good condition and has a rated lifting capacity equal to or greater than the weight being lifted. Lifting devices must be checked frequently for condition and continued conformance to rated load capacity. They should then be tagged with the inspected capacity together with the date of inspection.

Fully assembled pumps and pump package units are heavy and should only be moved using the specified lifting lugs or attachments. **Many individual components have lifting eyes or lugs which must not be used to lift assemblies, as they are designed to bear the weight of the component only.** Before lifting the individual component check to insure the lifting attachment is firmly secured to the component with undamaged, properly torqued fasteners, sound welds, or other secure attachments. Examine the lifting eyes, lugs, slots, holes or other projections to insure they are not cracked, otherwise damaged or badly worn. The repair of existing or addition of new welded lifting eyes, lugs or other projections should only be performed by experienced, qualified welders.

Package units should be lifted with spreaders connected to the lifting attachments normally built into the package unit support skid. Packages too large to lift fully assembled should be separated into small loads. For these smaller loads the lifting devices should be fastened to the lifting attachments normally built into the individual motor, engine, pump or transmission/torque converter, or their separate support skids.

When lifting subassembled components, for example a suction stabilizer attached to suction piping or a discharge pulsation dampener attached to a strainer cross and piping, use special lifting slings designed to safely support the combined weight of the components.

If a crane or hoist is being used to lift large components or assemblies, one or more persons should assist the operator from the ground with guide lines attached to the equipment being moved to properly position it and prevent uncontrolled movement.

When you start to lift a pump, package unit, subassemblies or individual components, and you observe the equipment is tilting or appears unbalanced, lower the equipment and adjust the lifting device to eliminate these improper lifting conditions before proceeding to move the equipment.

It is poor practice and dangerous to allow the equipment to pass over or close to your body or limbs. Be prepared to move quickly out of danger if equipment starts to fall, slip or move unexpectedly toward you.

PRESSURIZED PUMP SYSTEMS

DANGER

Fluids under high pressure can possess sufficient energy to cause personal injury, death and/or equipment damage either through direct contact with escaping fluid streams or by contact with loose objects the pressurized fluid propels.

Operating a pump against a blocked or restricted discharge line can produce excessive pressures in the entire discharge system, which can damage or burst discharge system components.

Continually monitor suction and discharge hose assemblies when the pump is operating for leakage, kinking, abrasion, corrosion or any other signs of wear or damage.

Worn or damaged hose assemblies should be replaced immediately. At least every six months examine hose assemblies internally for cut or blulged tube, obstructions and cleanliness. For segment style fittings, be sure that the hose butts up against the nipple shoulder, the band and retaining ring are properly set and tight and the segments are properly spaced. Check for proper gap between nut and socket or hex and socket. Nuts should swivel freely. Check the layline of the hose to be sure that the assembly is not twisted. Cap the ends of the hose with plastic covers to keep them clean until they are tested or reinstalled on the pump unit. Following this visual examination, the hose assembly should be hydro statically tested on the test stands having adequate guards to protect the operator, per the hose manufacturer's proof test procedure.

Component inspections should be performed more frequently than every six months if corrosive, flammable or hot (over 110°F) fluids are being pumped.

Proper packing selection is important for safe pump operation. Contact a Gardner Denver service representative for assistance in selecting the proper packing before beginning operation.

DANGER

Don not attempt to service, repair, adjust the packing or otherwise work on the pump while the unit is operating. Shut off the pump drive motor or engine and relieve the fluid pressure in the pump suction and discharge systems before any work or investigation is performed on the pump or pump systems.

Whenever the pump is operating, continually monitor the entire suction, discharge and pump lubricating systems for leaks. Thoroughly investigate the cause for leakage and do not operate the pump until the cause of the leak has been corrected. Replace any parts which are found to be damaged or defective. When a gasketed joint is disassembled for any reason, discard the used gasket and replace it with a new genuine Gardner Denver gasket before reassembling the joint.

In summary, high pressure fluid streams can possess sufficient energy to cause personal injury, death and/or equipment damage. These results can occur either through direct contact with the fluid stream or by contact with loose objects the fluid stream has propelled, if the pump system is improperly used, or if the fluid is misdirected or allowed to escape from defective or improperly maintained equipment.

FLAMMABLE, HOT, COLD OR CORROSIVE FLUID PUMPING

DANGER

Extreme caution must be exercised by trained and experienced operators when flammable, hot cold or corrosive fluids are being pumped, in order to avoid personal injury, death and/or equipment damage due to explosion, fire, burn, extreme cold or chemical attack

Never operate a pump which is pumping hydrocarbons or other flammable, hot, cold, or corrosive fluids when any part of the pump, suction system or discharge system is leaking. Stop the pump immediately if any leakage, other than a few drops per minute of packing weepage, is observed. Keep all flame, sparks, or hot objects away from any part of the pump, suctions system or discharge system. Shield the pump, suction system an discharge system to prevent any flammable, hot, cold or corrosive fluid leakage from dripping or spraying on any components, flame sparks, hot objects or people. Inspect the packing, gaskets and seals for fluid leakage frequently and replace worn or leaking parts.

Selection of the proper gaskets, seals and packing is even more critical when flammable, hot, cold or corrosive fluids are being pumped than when other, inherently less dangerous fluids are used. Contact a Gardner Denver service representative for assistance in selecting the proper gaskets, seals and packing before beginning operation.

Since some packing seepage is inevitable, a catch pan is required and must be connected to a drain line which conducts container located in a protected area. The entire drain system and container must be constructed of materials resistant to attack from the pumped fluid or from explosion or fire of the pumped fluid.

Before beginning pumping operations or starting the pump power source (whether an engine or electric or electric motor) check the atmosphere all around the pumping site for the presence of flammable or explosive vapors are detected. Hot surfaces, sparks, electric current or engine exhaust could ignite flammable or explosive vapors. Each engine used as a power source on pumping units where flammable or explosive vapors could form should be equipped with an air inlet shut-off. If flammable or explosive vapors are present in the pumping site atmosphere, an engine could continue to run on these vapors, even after the engine fuel line is shut-off, if an air inlet shut-off is not used.

In addition, on pumping units used where flammable or explosive vapors could from, all electric motors used as power sources must be of explosion proof construction and all electrical components and wiring must meet the current National Electrical Code for explosive atmospheres.

For these smaller loads the lifting devices should be fastened to the lifting attachments normally built into the individual motor, engine, pump or transmission / torque converter, or their separate support skids.

These precautions must be taken to avoid possible personal injury, death and/or equipment damage from, fire or burns.

SECTION 2

The pressure at any point in a liquid can be thought of as being caused by a vertical column of liquid which, due to it's weight, exerts a pressure directly related to the height of the column which is called the "static head" and expressed in terms of liquid feet.

The static head corresponding to any specific pressure is dependent upon the weight of the liquid according to the following formula:

$$\text{Head in Feet} = \frac{\text{Pressure in PSI x 2.31}}{\text{Specific Gravity}}$$

A centrifugal pump imparts velocity to a liquid, this velocity energy is transformed into pressure energy as the liquid leaves the pump. Therefore, the head developed is approximately equal to the velocity energy at the periphery of the impeller. This relationship can be shown by the following formula:

$$H = \frac{V^2}{2g}$$

Where H = Total Head Developed in Feed
V = Velocity At Periphery of Impeller in Feet Per Second
G = 52.2 ft/sec^2

We can predict the approximate head of any centrifugal pump by calculating the peripheral velocity of the impeller and substituting the above formula. The following formula may be used to calculate peripheral velocity:

$$V = \frac{\text{RPM x D}}{229}$$

Where D = Impeller diameter in inches

This demonstrates why we must **always think in terms of feet of liquid rather than pressure when working with centrifugal pumps.** A given impeller diameter and speed will raise a liquid to a certain height regardless of the weight of the liquid as shown in FIGURE 2-1.

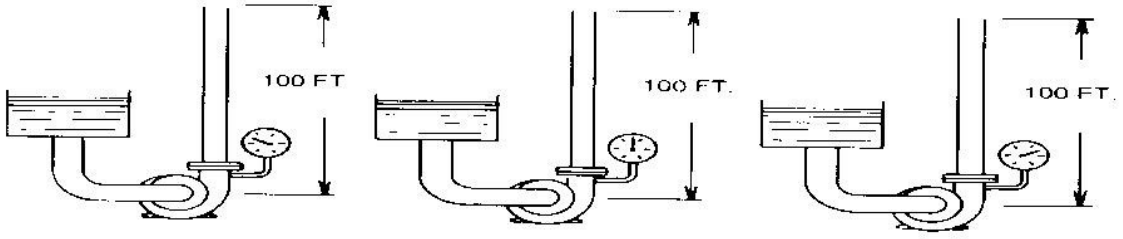


Figure 2-1 – Identical Pump Handling Liquids of Different Specific Gravities

Light Crude, Specific Gravity = 0.60
Discharge = 100'x0.60 = 26 PSI
Pressure 2.31

Water, Specific Gravity – 1.0 13#
Discharge = 100'x1.0 = 43 PSI
Pressure 2.31

Cement, Specific Gravity = 1.5
Discharge = 100'x1.5 = 65PSI
Pressure 2.31

All of the forms of energy involved in a liquid flow system can be expressed in terms of feet of liquid. The total of these various heads determines the total system head or the work which a pump must perform in the system. The various forms of head are defined as follows. Refer to FIGURE 2-2.

SUCTION LIFT exists when the source of supply is below the center line of the pump. Thus the STATIC SUCTION LIFT is the vertical distance in feet from the centerline of the pump to the free level of the liquid to be pumped.

STATIC HEAD exists when the source of supply is above the centerline of the pump. Thus the STATIC SUCTION HEAD is the vertical distance in feet from the centerline of the puMp to the free level of the liquid to be pumped.

STATIC DISCHARGE HEAD is the vertical distance in feet between the pump centerline and the point of free discharge or the surface of the discharge liquid.

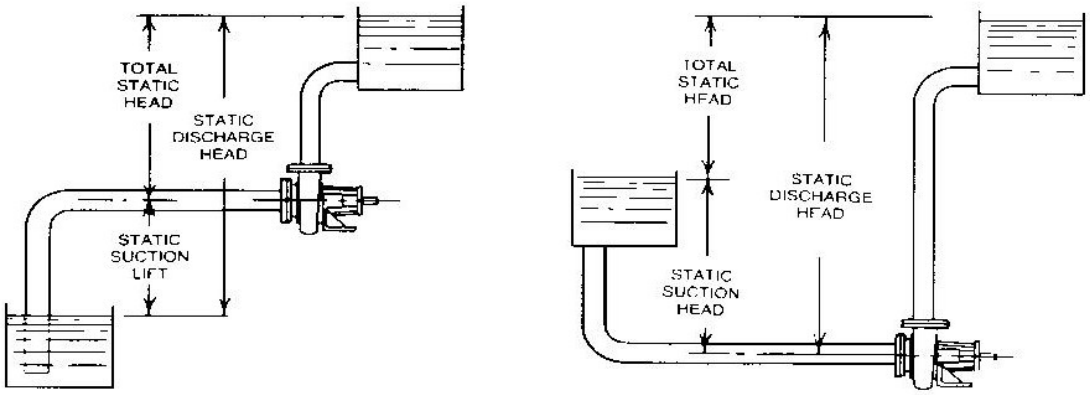
FRICTION HEAD (h_f) is the head required to overcome the resistance to flow in the pipe and fitting. It is dependent upon the size and type of pipe, flow rate, and nature of the liquid.

VELOCITY HEAD (h_v) is the energy of a liquid as a result of its motion at some velocity V. It is the equivalent head in feet through which the water would have to fall to acquire he same velocity, or in other words, the head necessary to accelerate the water. Velocity head can be calculated from the following formula.

$$Hv = \frac{V^2}{2g}$$

Where g = 32.2 ft./Sec.
V = liquid velocity in feet per second

The velocity head is usually insignificant and can be ignored in most high head systems. However, it can be a large factory and must be considered in low head systems.



Suction Lift
Showing Static Heads in a Pumping System Were the Pump is Located Above the Suction Tank (Static Suction Head)

Suction Head
Showing Static Heads in a Pumping System Where the Pump is Located **Below the Suction Tank (Static Suction Head)**

Figure 2-2 – Static Head Pump Locations

PRESSURE HEAD must be considered when a pumping system either begins or terminates in a tank which is under some pressure other that atmospheric. The pressure in such a tank must first be converted to feet of liquid. A vacuum in the suction take or a positive pressure in the

discharge tank must be added to the system head. Whereas a positive pressure in the suction tank or vacuum in the discharge tank would be subtracted.

The following formula is for converting inches of mercury vacuum into feet of liquid.

$$\text{Vacuum, Ft of liquid} = \frac{\text{Vacuum, in Hg x 1.13}}{\text{Specific Gravity}}$$

The above forms of head, namely static, friction, velocity, and pressure, are combined to make up the total system head at any particular flow rate. Following are definitions of theses combined or "Dynamic" head terms as they apply to the pump.

TOTAL DYNAMIC SUCTION LIFT (h_s) is the static suction lift plus the velocity head at the pump suction flange plus the total friction head in the suction line. The total dynamic suction lift, as determined on pump test, is the reading of a gage on the suction flange, converted to feet of liquid and corrected to the pump centerline, minus the velocity head at the point gage attachment.

TOTAL DYNAMIC SUCTION HEAD (h_s) is the static suction head minus the velocity head at the pump discharge flange plus the total friction head in the discharge line. The total dynamic discharge head, as determined on pump test, is the reading of a gage at the discharge flange, converted to feet of liquid and corrected to the pump centerline, plus the velocity head at the point of gage attachment.

TOTAL DYNAMIC DISCHARGE HEAD (h_d) is the static discharge head plus the velocity head at the pump discharge flange plus the total friction head in the discharge line. The total dynamic discharge head, as determined on pump test, is the reading of a gage at the discharge flange, converted to feet of liquid and corrected to the pump centerline, plus the velocity head at the point of gage attachment.

TOTAL HEAD (H) pr TOTAL DYNAMIC HEAD (TDH) is the total dynamic discharge head minus the total dynamic suction head or plus the total dynamic suction lift.

NET POSITIVE SUCTIO HEAD (NPSH)

NPSH may be defined as the total suction head in feet absolute, determined at the suction nozzle and corrected to datum, less the vapor pressure of the liquid in feet absolute. Simply stated, is an analysis of energy conditions on the suction side of a pump which will determine if a liquid will vaporize at the lowest pressure point in a pump.

The majority of centrifugal pump problems are a direct result of less than required NPSH. We will attempt to list several things that can be done on the average hook up to improve or eliminated these problems.

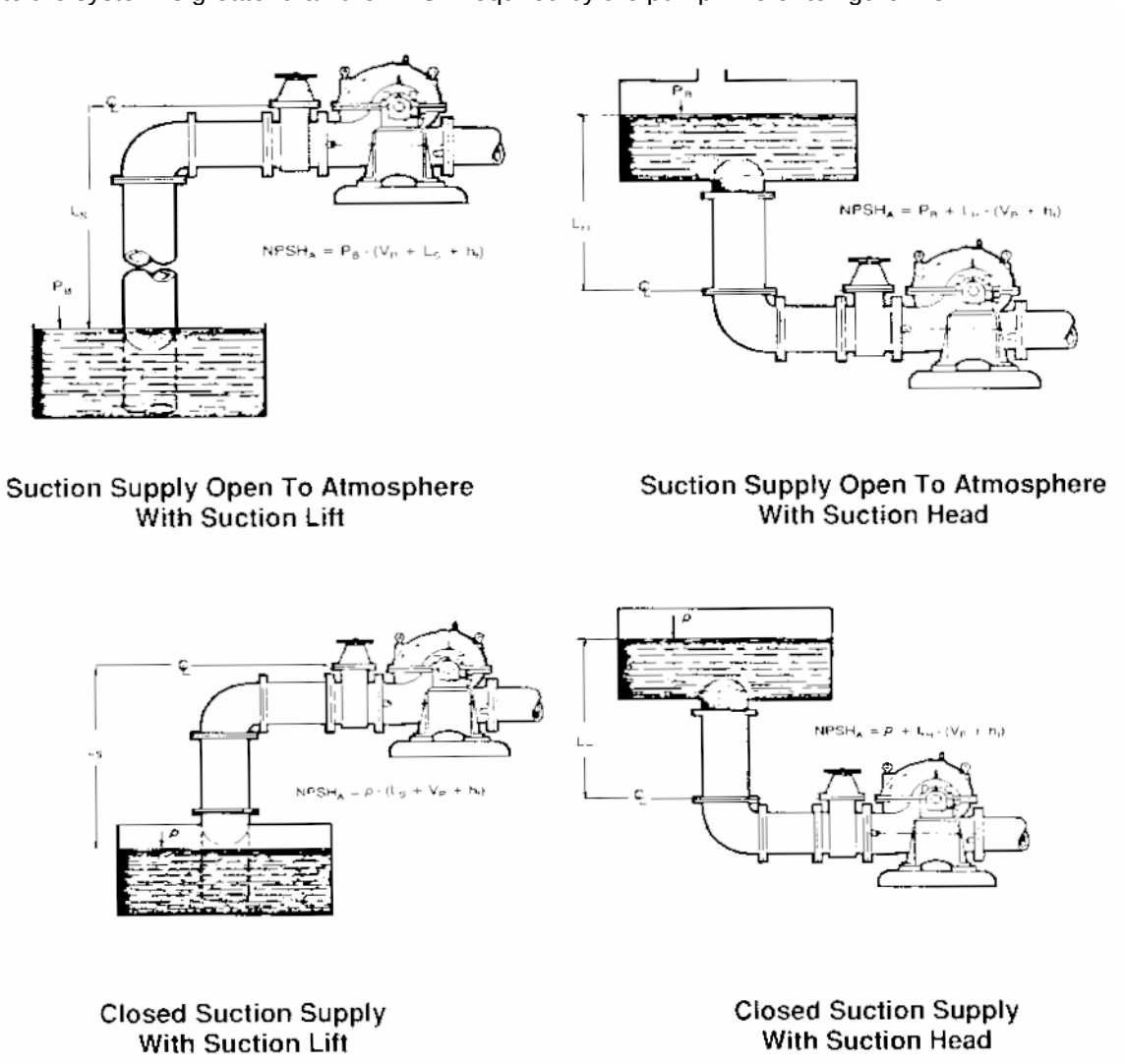
While you will not be expected to calculate available NPSH it is important to understand this characteristic of centrifugal pumps so as to avoid problems when laying and hooking up suction hose and lines.

Although most factors of available NPSH are controllable, friction loss is usually easier than th other. Keep suction lines as short and straight as possible. The maximum volume for a 4" suction hose is 8 BPM under ideal conditions. This can change with long lines, high lift and many other conditions which would indicate a lower rate. The higher the flow rate, the higher the friction loss which can result in air or vapor separation. This is always complicated further by elbows, tees and other sharp turns. Especially those located near the pump suction where they can set up uneven flow patterns or vapor separation which causes uneven filling of the impeller vanes. This can affect the hydraulic balance of the impeller, leading to possible cavitation, excessive shaft deflection breakage and premature bearing and impeller retaining bolt failures.

One of the most frequently encountered problems when there is insufficient NPSH available is cavitation. This term is used to describe the phenomenon which occurs in pumps when the pressure of the liquid being pumped is reduced to a value equal to or below its vapor pressure

and small bubbles move along the impeller blades to higher pressure area, where they rapidly collapse and implode. This is usually heard as a growling or rumbling sound, much like the noise you would hear if you were pumping gravel. The forces are sometimes high enough to cause small fatigue failures on the impeller vane surfaces. This of course is progressive under long period of this condition and the pitting and fatigue failure are refereed to as “cavitation erosion” which can sometimes be severe enough to cause vibration, shaft and bearing failure.

The only way to prevent the undesirable effect of cavitation is to insure that the NPSH available to the system is greater than the NPSH required by the pump. Refer to figure 2-3



P_B = Barometric pressure, in feet absolute.
v_p = Vapor pressure of the liquid at maximum pumping temperature in feet absolute.
P = Pressure on surface of liquid in closed suction tank, in feet absolute.
L_S = Maximum static suction lift in feet.
L_H = Minimum static suction head in feet.
h_1 = Friction loss in feet in suction pipe at required capacity.

Figure 2-3 - Net Positive Suction Head (NPSH) and Cavitation

PARALLEL & SERIES OPERATIONS

Sometimes it is necessary to operate two or more pumps in conjunction with one another. The operation will be either parallel or series depending on the arrangement. Refer to FIGURE 2-4.

In a parallel operation, the discharge head is equal to that of one pump, and the volume is equal to the total of the two. In this case, care should be exercised with the suction manifold to insure that one pump does not starve. Also the discharge capabilities of each pump should be fairly close to avoid one pump moving fluid back through the second pump.

The results of a series operation is the opposite of parallel systems. The volume is limited to the capacity of one pump but the head is equal to the sum of the two. This occurs because performance curves denote the differential head across the pump so the second pump will add its head to the head supplied to its suctin by the first pump. If this is attewmpte4d, it is imperative to know the maximum working case pressure of the pump to avoid bursting the second pump. In oil field service, this type of hook up is seldom if ever used, never with slurry, In industrial service, it is done on a limited basis pumping fluids. Due to the high incidence of seal failure in the second pump, this type if operation should be discouraged.

EXAMPLE

Two pumps, each having the capacity of 20 BPM @ 100 ft. of head, are to be operated together. The output for parallel and series operations is as follows:

Parallel Operations:
Volume = 20 BPM + 20 BPM = 40 BPM
Head = 100 ft.

Series Operation:
Volume = 20 BPM
Head = 100 + 100 = 200 ft.

Although the theoretical head for series operation is 200 ft., the actual head will be somewhat lower. This is due to the friction loss in the manifold between pumps and will vary with volumes and manifold.

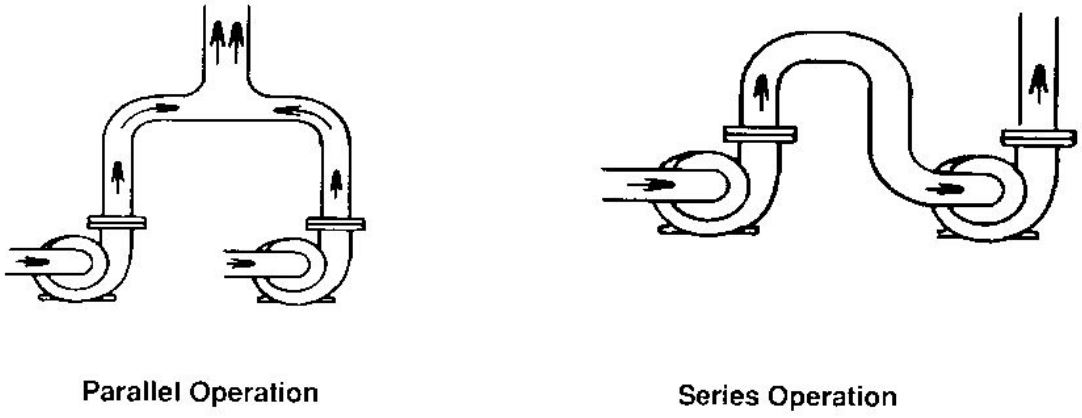


Figure 2-4 – Parallel and Series Operation

TROUBLE SHOOTING SHART

Complaint

1. Pump will not “pick up prime”.

a. Pump too high above source of liquid.
b. Seals or packing taking in air around shaft.
c. Too much head space between impeller and front wear plate.
d. Pump speed too slow.
e. Restriction or blockage in suction.
f. Worn parts, impeller, wear plates or volute.
g. Impeller loose on shaft or key broken.

2. Low discharge pressure.
   a. Worn parts, impeller, wear plates, or volute.
   b. Restriction in suction.
   c. Pump speed too slow.
   d. Too much head space between impeller and front wear plate.

3. Pump noisy or vabrates.
   a. Cavitation
   b. Worn bearings.
   c. Out of balance.
   d. Loose mounting bolts.
   e. Misaligned coupling.
   f. Speed too high.
   g. Broke impeller vane.

4. Pump leaks around bolts at volute.
   a. Wear plates not sealing at volute.

5. Slurry pumps
   Slurry pumps will sometimes hold a normal discharge pressure and on hydraulically driven pumps the hydraulic pressure will be normal when pumping water. As the slurry weight increases the pumps and hydraulic pressures become erratic, the pump suddenly stops pumping and hydraulic pressure will usually drop to 25% of normal. The condition can almost always be traced to defective shaft seals in pump or seals that have been installed improperly with all the seal lips facing impeller. Next to the last seal in any mechanical seal arrangement must always face opposite the impeller to prevent air pick up around shaft.

   To determine if the problem are the seals or a hydraulic problem, stall the pump (hydraulically driven unit only) and observe hydraulic pressure. If it is normal (usually 2600-2800 psi), the problem are the seals in the pump and not the hydraulic system.

SQUARE BRAIDED PACKING

This section covering square braided packing is being included as an alternate method of packing as most pumps are equipped with mechanical seals at time of construction. One

advantage of the square braided packing is that in an emergency, extra packing can usually be added very quickly. If a mechanical seal fails, it can sometimes be a major operation to replace these seals. The disadvantage of square braided packing is that it requires more maintenance, and it can burn out in minutes if not properly adjusted For cooling and lubrication, it should leak a small amount except as noted in number 7, page 8. Tests show that the life is approximately 400% less than for mechanical seals.

Asbestos packing is no longer available. Tests indicate the following listed packing may be substituted with little or no problems so long as proper adjustment is maintained.

Garlock #98 Temperature to:	650° F (345° C)
Parker #5700	800° F (426° C)
Teflon from most manufacturers	550° F (288° C)

None of the three packing materials listed above need external lubrication except during installation and break-in.

PACKING AND ADJUSTMENT PROCEDURE FOR SQUARE BRAIDED PACKING

1. Remove old packing from the stuffing box.
2. Inspect shaft and stuffing box for cleanliness and wear. Replace worn parts and clean stuffing box as required.
3. Cut rings to proper length if they have not been provided pre-cut, by use of spare shaft or packing cutter. Always cut ends on a bias to prevent leakage.
4. Lubricate I.D. of each ring prior to installation with some type of break-in lubricant such as chassis lube. Lubricate the I.D. only.
5. Install each ring individually and seat firmly to the bottom of stuffing box or previously installed ring. Rotate the joint or open end of each successive ring 90° apart, i.e., 12:00, 3:00, 6:00, 9:00 o'clock when using four rings or more. This is done to minimize leakage paths through the body of packing set.
6. After the last ring has been installed, tighten the packing follower only hand tight.
7. Open suction and discharge valves, start pump and allow packing to leak for 10-15 minutes without adjusting the packing follower. During this period pump should be run at approximately ½ speed. This procedure is very important as it allows the packing to take a "set" and conform to the contour of the shaft and stuffing box.
8. After run in period has been completed, start adjusting packing follower in very minor increments allowing 5-10 minutes between adjustments until leakage has reached a very low level. When pumping water it is always advisable to let packing leak a small amount. This provides cooling and lubrication. In preparing for pumping latex or other fluids where no leakage can be tolerated, the same procedure should be followed and packing should be tightened slowly to just the point where no leakage occurs.

CAUTION

The previously listed packing is designed to run without lubrication except for break-in period. It should never be tightened any more than is necessary to stop excessive leakage as this increases temperature and accelerated shaft wear.

CAUTION

A lantern gland is installed in square braided packing which requires lubrication. Some types of packing require NO lubrication (except as noted in Number 4, this page). If non-lubricated packing is used, the lantern gland should be removed and replaced with ne extra packing ring. Refer to Figures on page 29.

PACKING PUMP WITH MECHANICAL OIL SEALS

1. Remove old packing or oil seals from stuffing box.
2. Inspect stuffing box for cleanliness and wear. Clean as required.
3. Install first two oil seals with lips facing the impeller.
4. The next seal is installed with the lip facing rear of pump and away from impeller. This seal prevents air pick up around shaft.
5. The last seal is installed with lip facing impeller as first seals were installed. Some pumps require a small spacer behind th elast seal. If a print of pump is not available, it may be assumed that a spacer will be needed if last seal is not flush with rear of stuffing box.
6. Install packing fland or suffing box nut and tighten at this time.
7. Make sure that the oiler is operating properly.
8. Start pump and circulate water for five minutes, check for leaks andmake sure oiler cycles whild pump is running.
9. No further adjsutments will be necessary for the life of the seals.

GENERAL TIGHTENING TORQUE FOR BOLTS, NUTS AND TAPERLOCK STUDS

The following charts give the standard torque values for bolts, nuts and studs of SAE Grade 5 or better quality. Exceptions are given in other sections of the Service Manual where needed.

Use these torques for bolts and nuts with standard threads (conversions are approximate).

THREAD DIAMETER		STANDARD TORQUE	
iches	millimeters	lb. ft.	N • m
1/4	6.35	9 ± 3	12 ± 4
5/16	7.94	18 ± 5	25 ± 7
3/8	9.53	32 ± 5	45 + 7
7/16	11.11	50 ± 10	70 + 15
1/2	12.70	75 ± 10	100 ± 15
9/16	14.29	110 ± 15	150 ± 20
5/8	15.88	150 ± 20	200 ± 25
3/4	19.05	265 ± 35	360 ± 50
7/8	22.23	420 ± 60	570 ± 80
1	25.40	640 ± 80	875 ± 100
1-1/8	28.58	800 ± 100	1000 ± 150
1-1/4	31.75	1000 ± 120	1350 ± 175
1-3/8	34.93	1200 ± 150	1600 ± 200
1-1/2	38.10	1500 ± 200	2000 ± 275

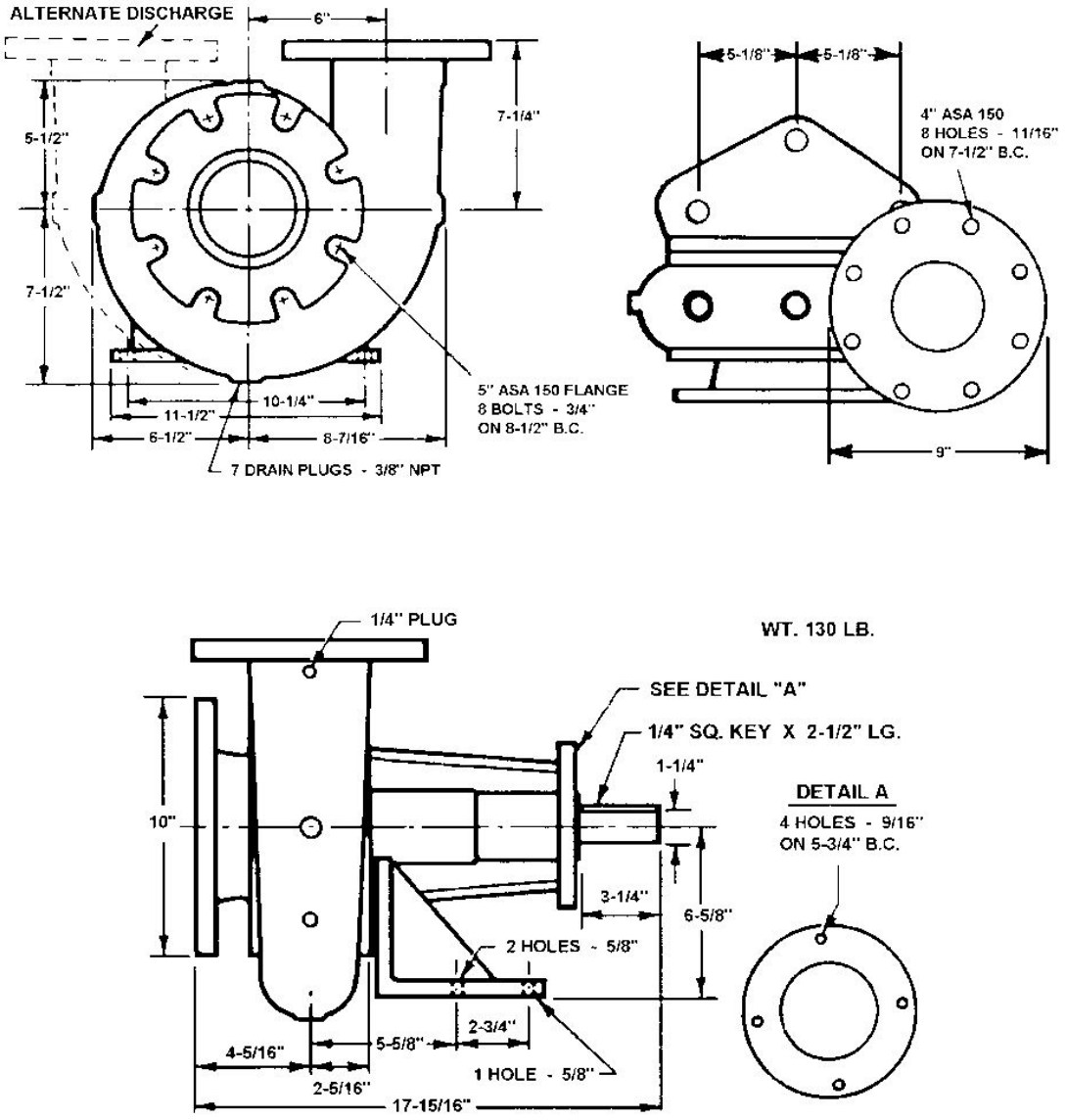


Figure 2-6 – Installation Dimensions

Note:
Assembly shown is Counterclockwise Pump

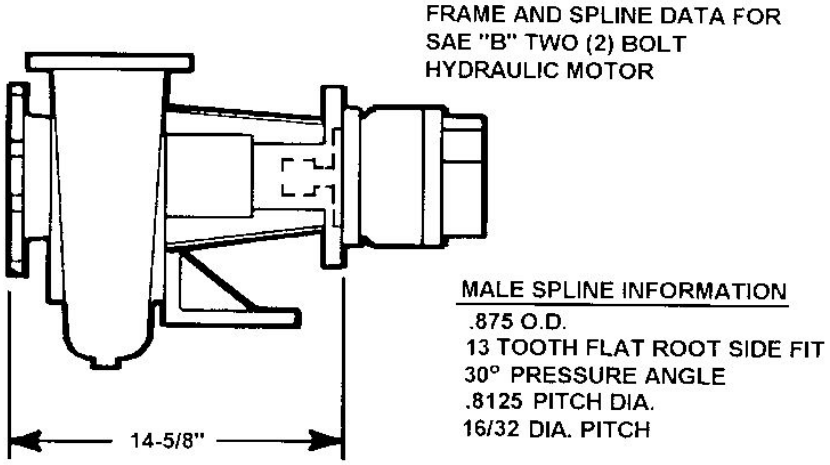


Figure 2-7 – Hydraulic Motor Mounting Specifications

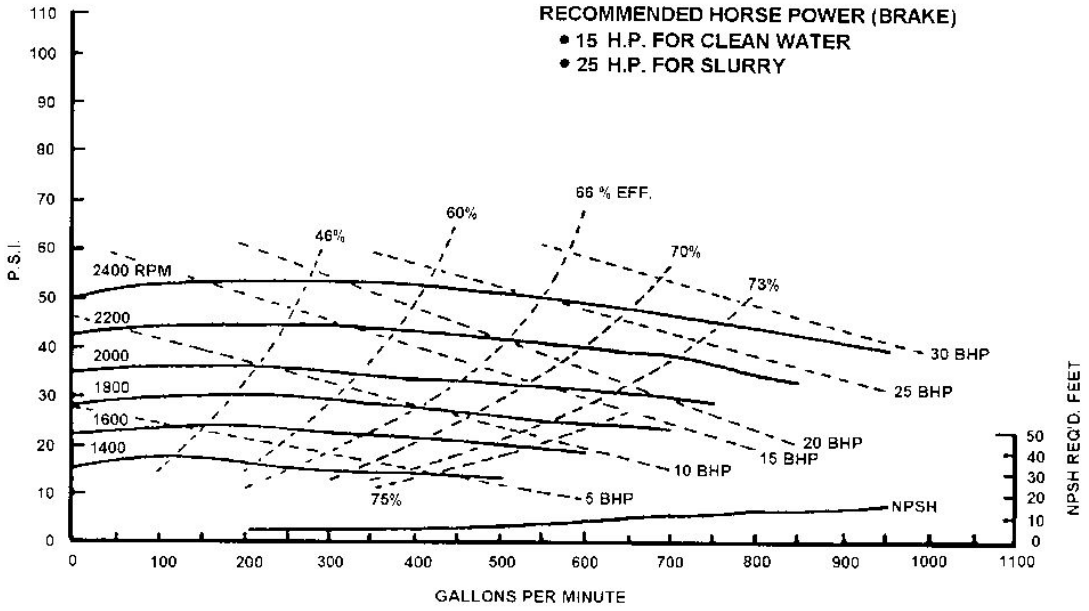
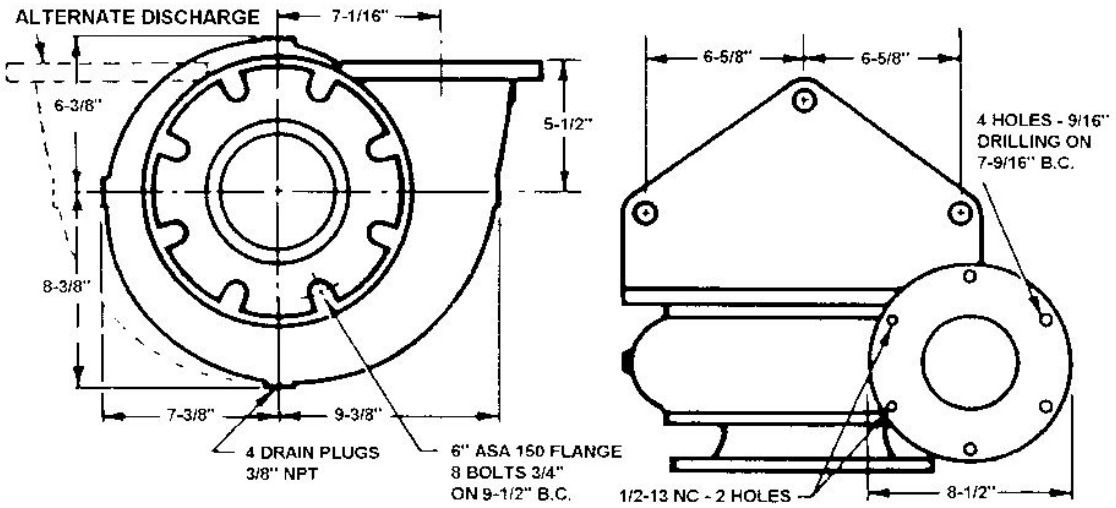
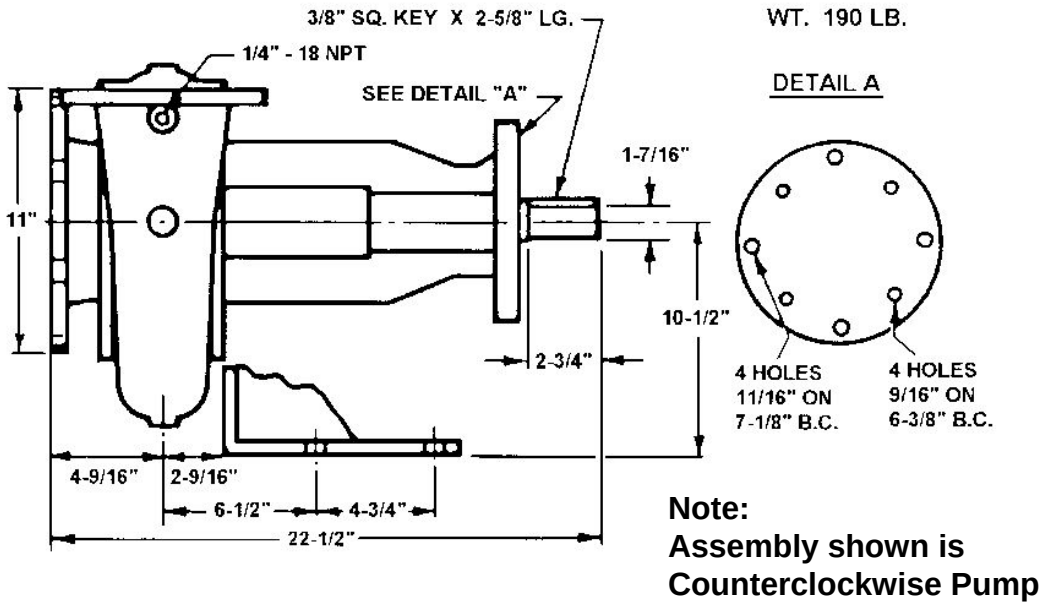


Figure 2-8 – Performance Curve





Note:
Assembly shown is Counterclockwise Pump

Figure 2-9 – Installation Dimensions

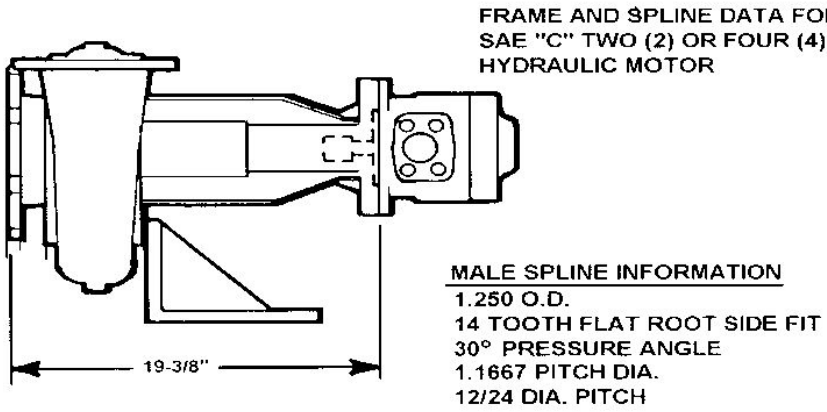


Figure 2-10 – Hydraulic Motor Mounting Specifications

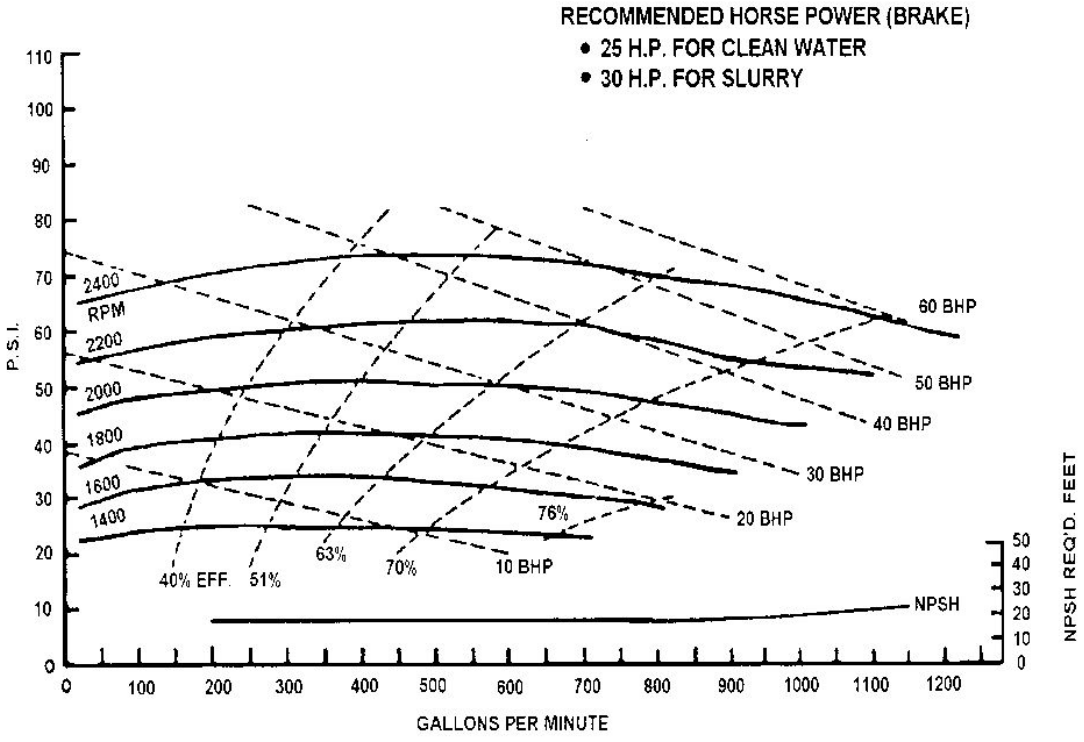


Figure 2-11 – Performance Curve

The 4" x 5" and the 5" x 6" pumps are similar except for the physical size and the packing arrangement in the stuffing box. Therefore only one set of photos and instructions will be used for maintenance and overhaul of these two pumps.

If the entire pump assembly as shown in FIGURE 3-1 is removed from the pumping unit, start disassembly by removing the entire row of nuts around the suction adaptor.

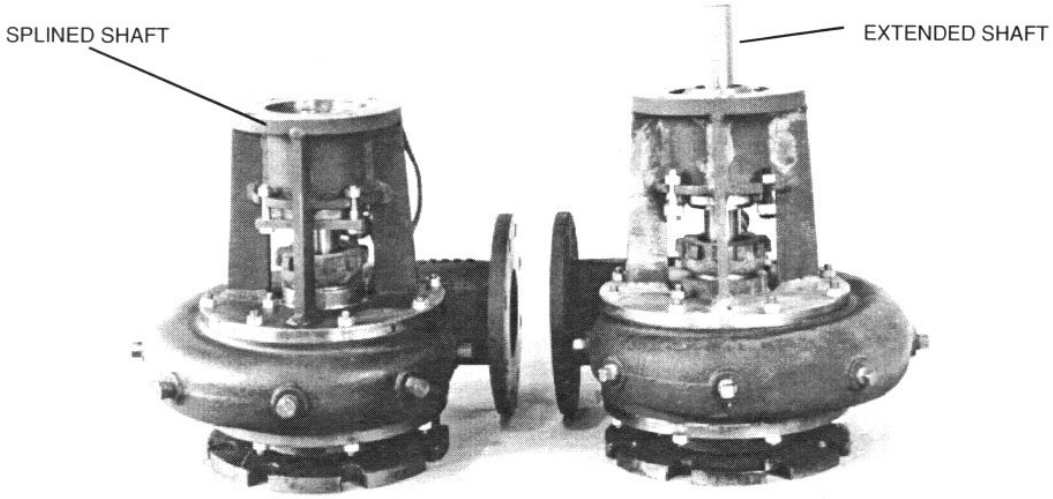


Figure 3-1

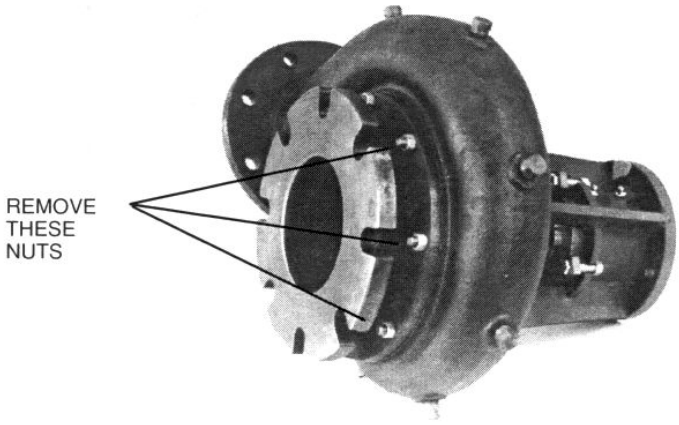


Figure 3-2

After the nuts are removed, pull the suction adaptor and front wear plate out as an assembly. See FIGURE 3-3.

FIGURE 3-4 shows the suction adaptor and front wear plate removed from the volute.

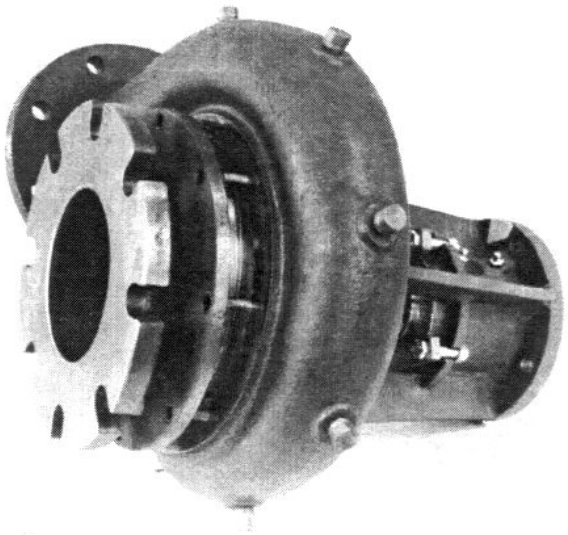


Figure 3-3

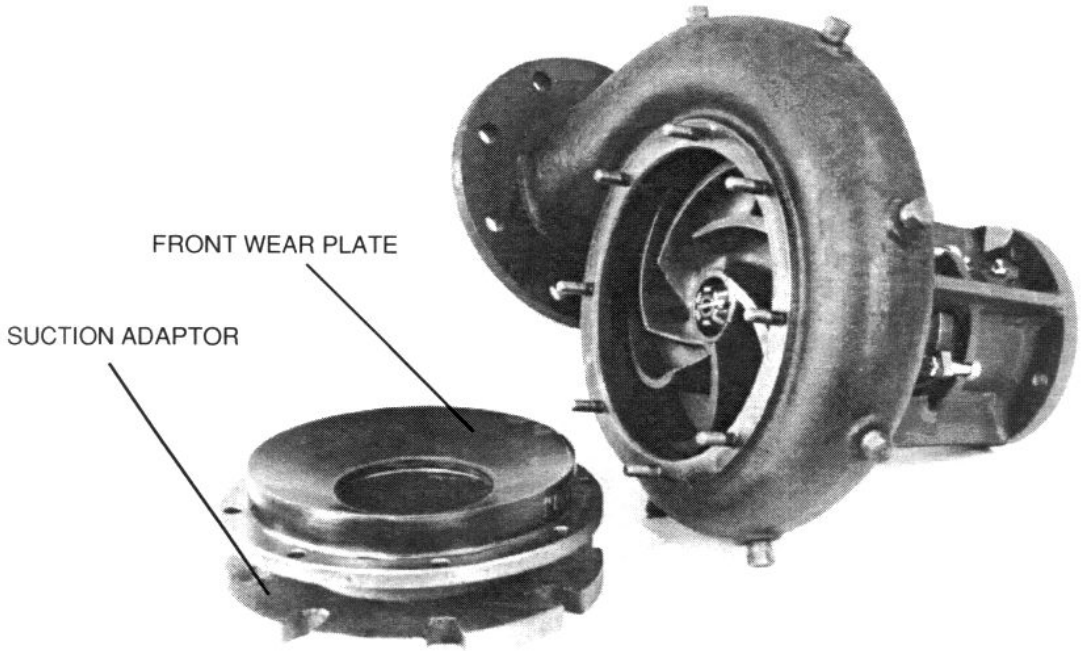


Figure 3-4

Remove the two nuts as shown in FIGURE 3-5 to separate the front wear plate from the suction adaptor.

After the two nuts are removed, separate the front wear plate from the suction adaptor. See FIGURE 3-6.

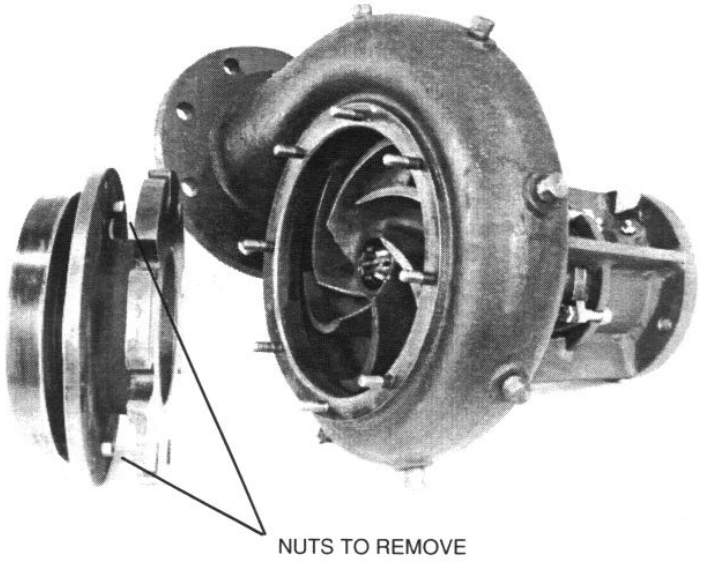


Figure 3-5

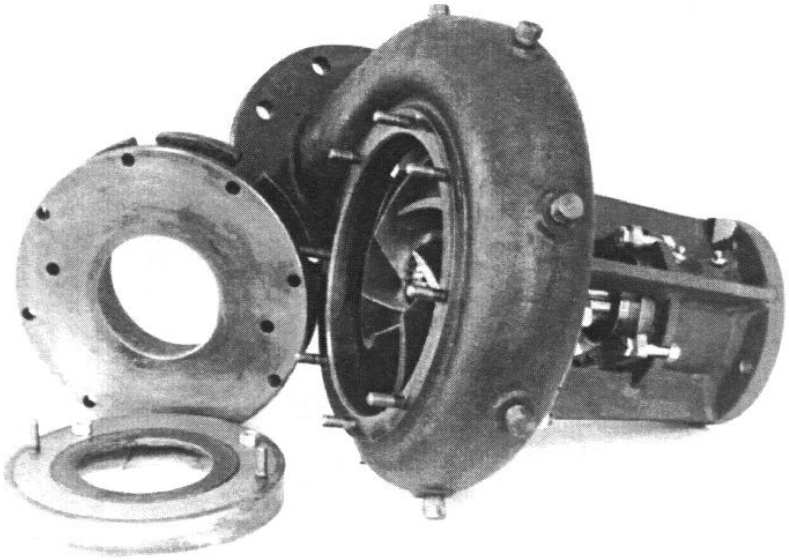


Figure 3-6

Remove the setscrew, impller retaining bolt and lock as shown in FIGURE 3-7.

Remove the impeller assembly. See FIGURE 3-8.

Remove two nuts from the rear of the wear plate, pry evenly on the heads of the wear plate studs. This will ppush the wear plate out of the housing which will give access to the stuffing ox. Remove the lubricator fitting from the stuffing box and then slide the box off over the shaft and out of the pump housing. See FIGURE 3-9.

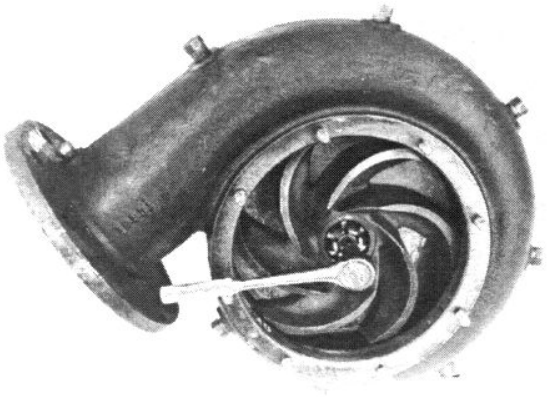


Figure 3-7

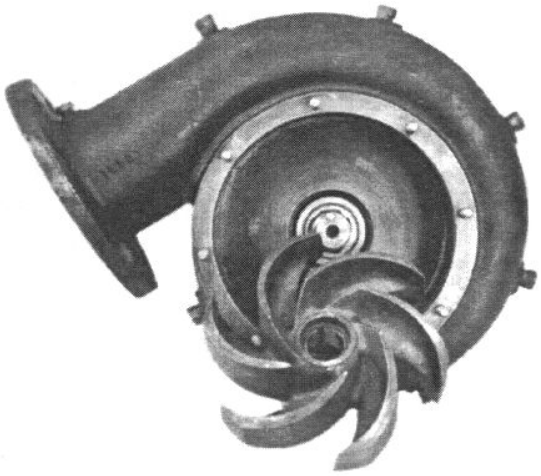


Figure 3-8

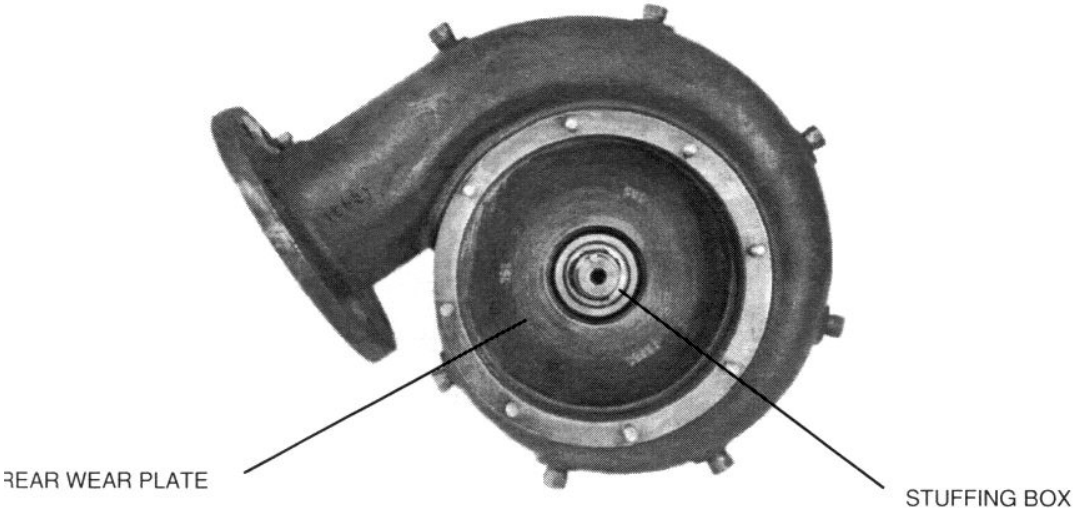


Figure 3-9

In the volute and suction adaptor are to be left on the pumping unit and only the rotating assembly is to be removed for service, remove the complete row of bolts as indicated in FIGURE 3-10.

Before removing the rotating assembly, put indexing marks on the pump frame and volute with paint or center punch so that the parts can be returned to the original position when the pump is assembled. See FIGURE 3-11.

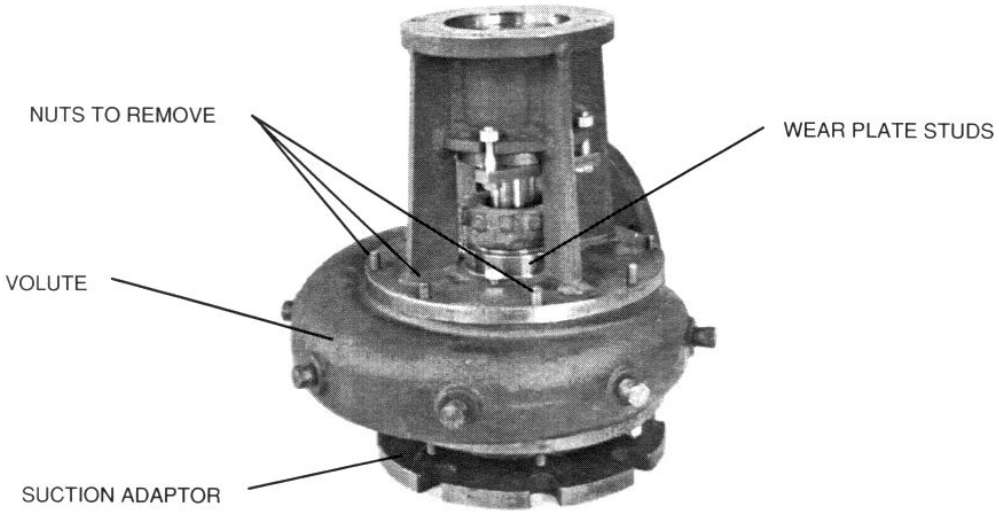


Figure 3-10

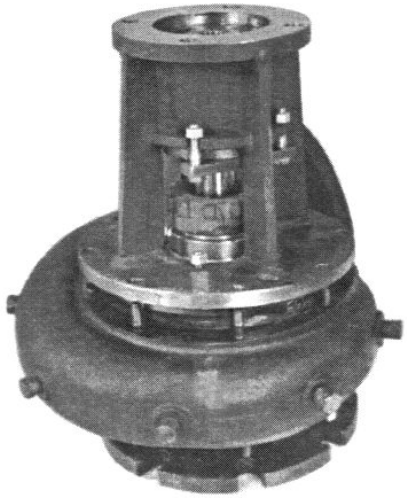


Figure 3-11

REMOVAL OF ROTATING ASSEMBLY ONLY - If only rotating assembly will be removed, start disassmbly here.

Remove pump frame bolts, oiler line, base bolts and motor retaining bolts as shown in FIGURE 3-12.

On units with extended shaft and mechanical drive, remove couplings or U joints at this time.

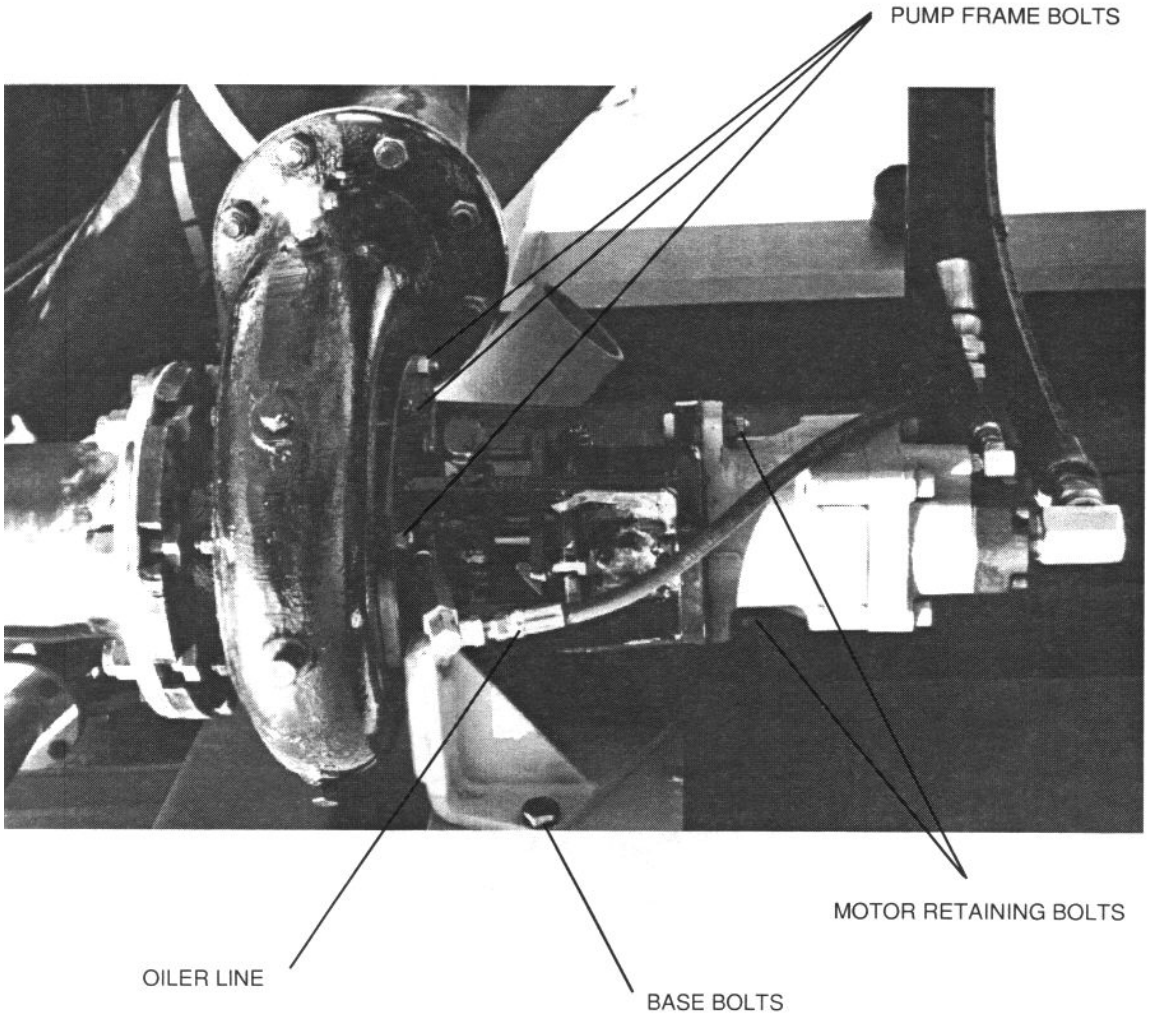
If the pump is driven by hydraulic motor, remove the bolts that secure the motor to the pump frame and pull the motor out of the splines.

Remove the oiler line to the stuffing box.

Remove the base plate bolts.

Remove the row of bolts that secures the pump frame to the volute.

Pull the rotating assembly out of the volute and start disassembly as indicated on page 24.



Remove the set screw, bolt and lock assembly from the impeller and shaft. See FIGURE 3-13.

The impleller may now be removed with two heavy screwdrivers on a thin pry bar. See FIGURE 3-14.

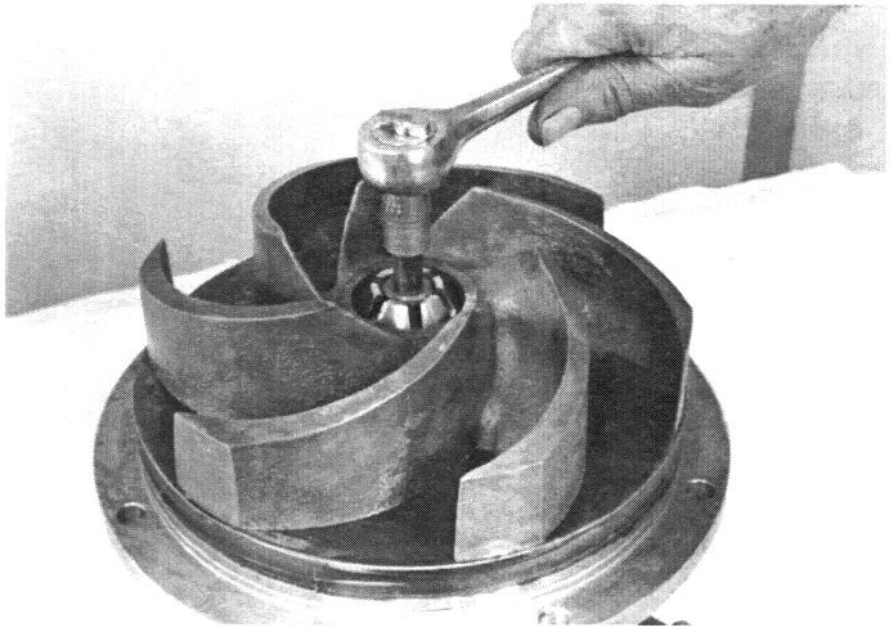


Figure 3-13

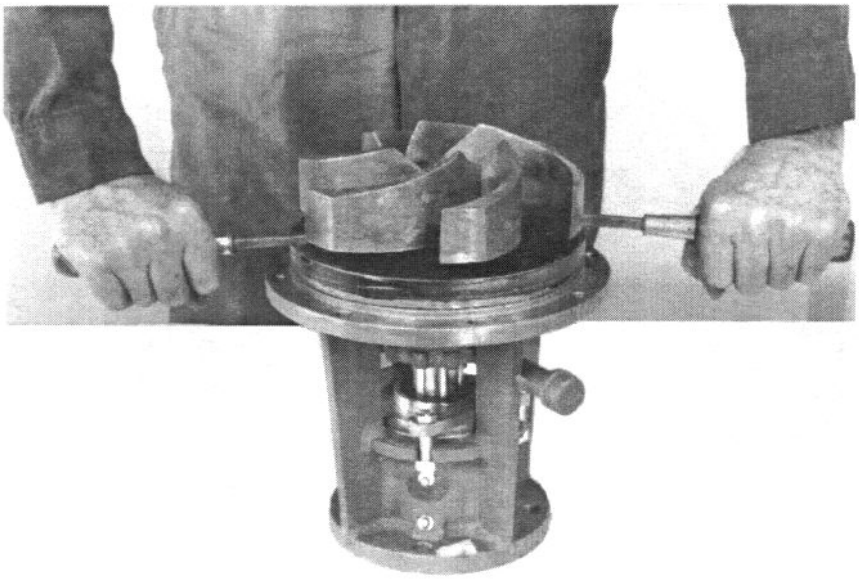


Figure 3-14

Remove the two nuts from the rear of the wear plate and separate the plate from the from. See FIGURE 3-15.

Remove the lubricator fitting from the stuffing box as shown in FIGURE 3-16.

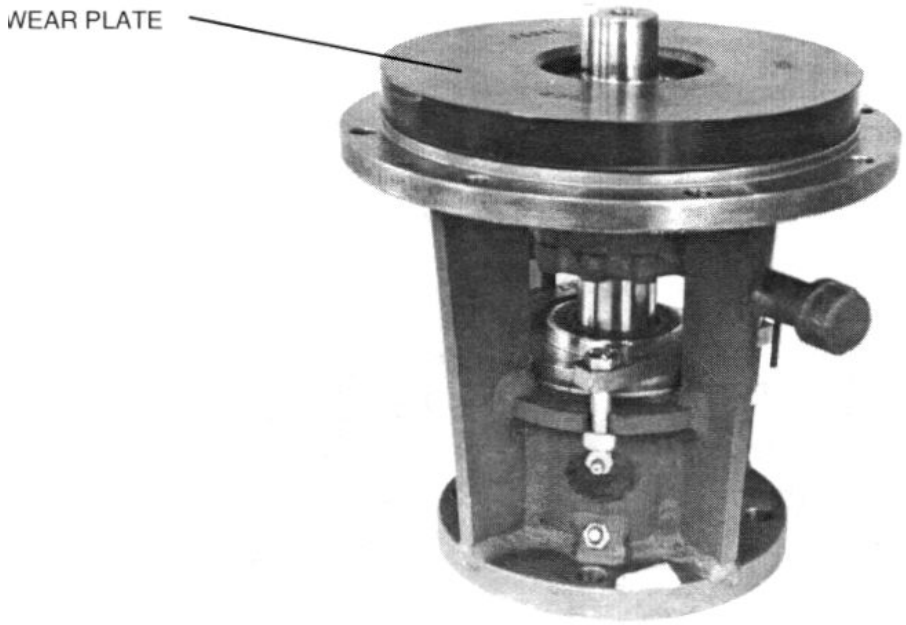


Figure 3-15

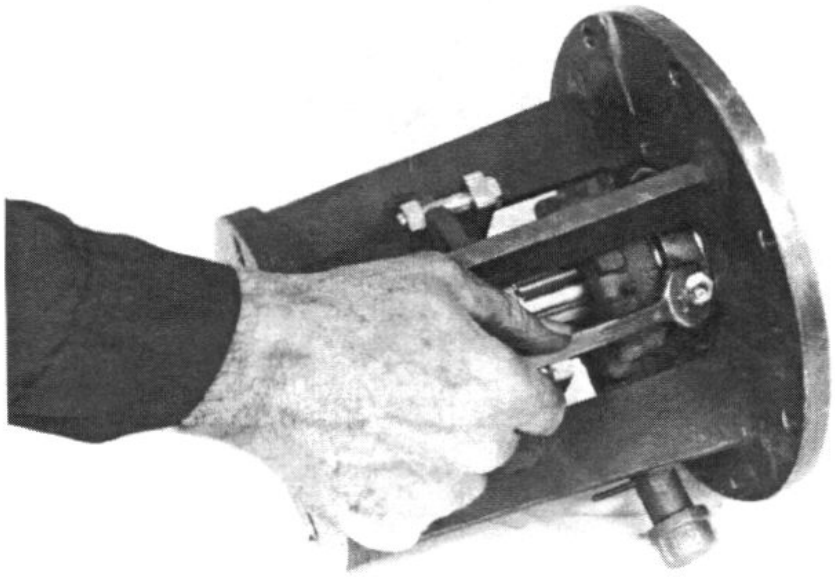


Figure 3-16

Remove the stuffing box from the frame as shown in FIGURE 3-17.

Remove the four bolts and nuts from the front bearing retainer bars. See FIGURE 3-18.

Use a pipe wrench to remove the cap from the locking assembly. Remove the lock and spring. See FIGURE 3-19.

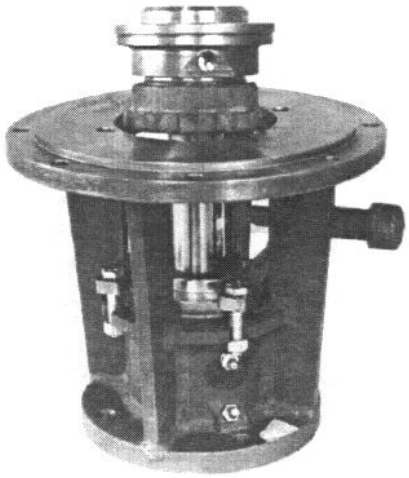


Figure 3-17

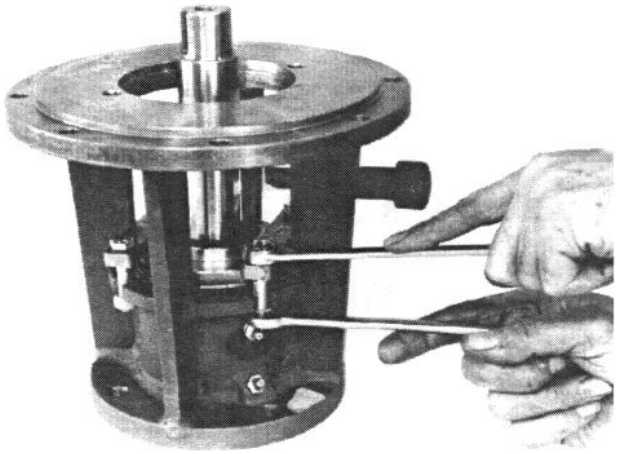


Figure 3-18

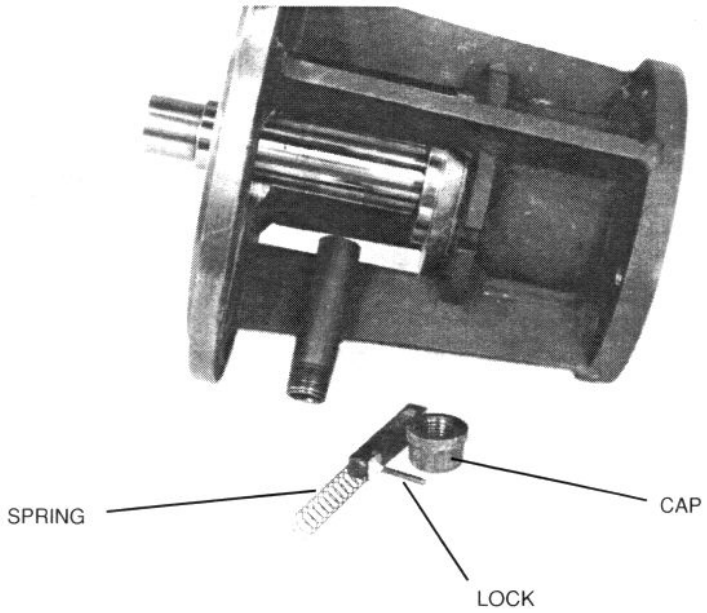


Figure 3-19

Pull the shaft and bearing assembly from the housing as shown in FIGURE 3-20.

When the shaft and bearing assebly is removed, this will allow the bearing shims to fall free. Save these shims as they will be needed during reassembly to get he proper head spaceon the impeller. See FIGURE 3-21.

If the bearing are to be replace, pry the locking washer tang out of the slot in the bearing retainer nut as shown in FIGURE 3-22.

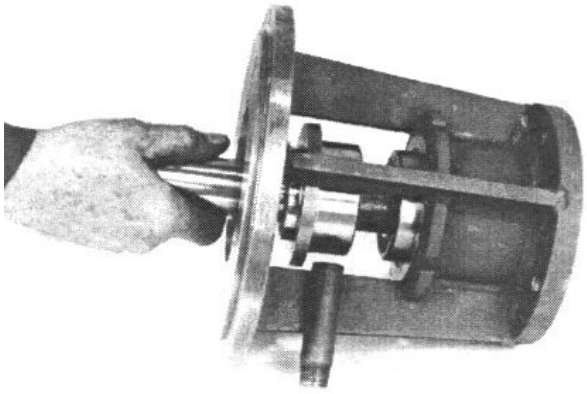


Figure 3-20

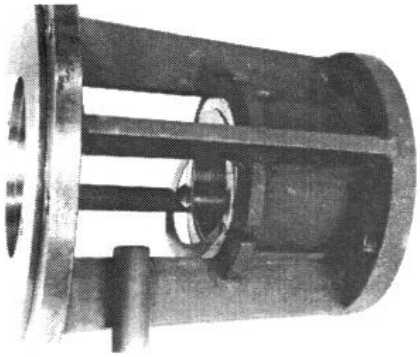


Figure 3-21

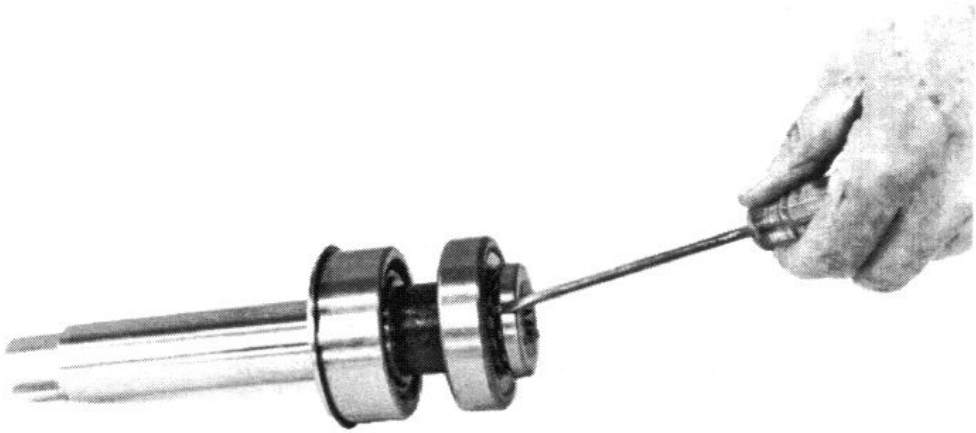


Figure 3-22

The nut may now be removed with a blunt punch or chisel. See FIGURE 3-23.

After the nut and lock are remove, the bearings and spacer may be pressed off the rear of the shaft.

Inspect for wear or damage as shown in FIGURE 3-24. If the shaft is damaged, rough or has grooves worn more than .010" (.254 mm) deep in the area shown, the shaft should be replaced.

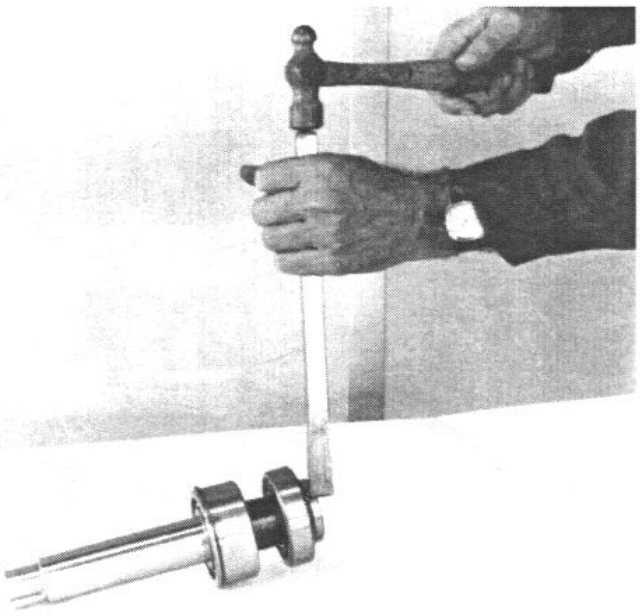


Figure 3-23

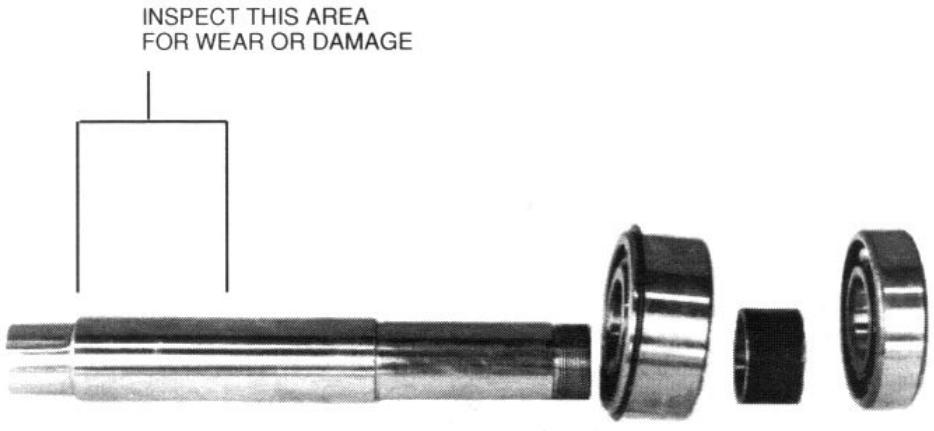


Figure 3-24

STUFFING GOX PACKED WITH MECHANICAL OIL SEALS (Qty. of 3 or 4) – See FIGURE 3-25 for identification and placement of parts.

When non-lubricated packing is required, the lantern gland should be removed and replaced with one extra packing ring.

To reassemble, insert the shaft, front bearing retainer, bearings, spacer, lock and nut as an assembly, into the pump frame. Replace the shims that were removed during disassembly under the front bearing snap ring and hold in place with the front bearing retainer. See FIGURE 3-26.

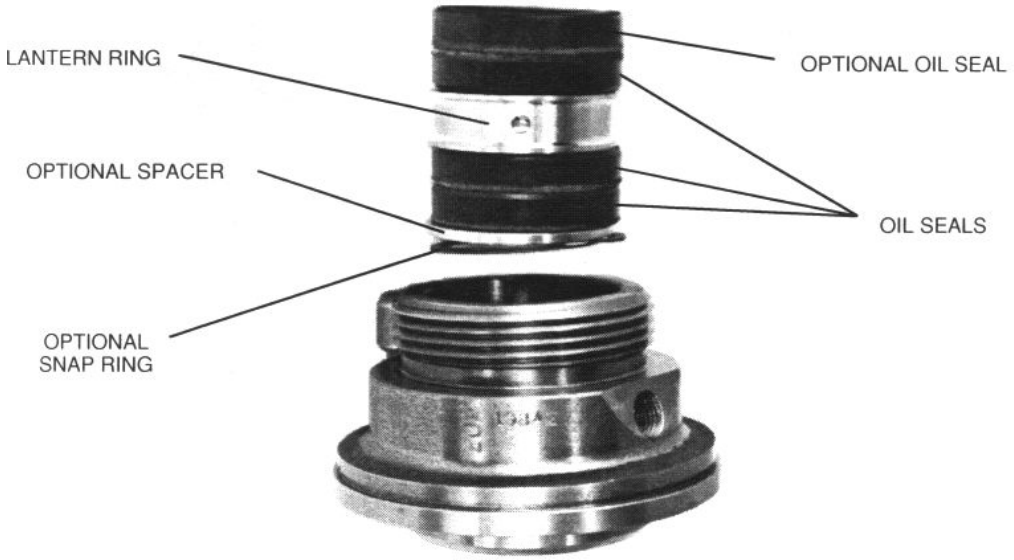


Figure 3-25

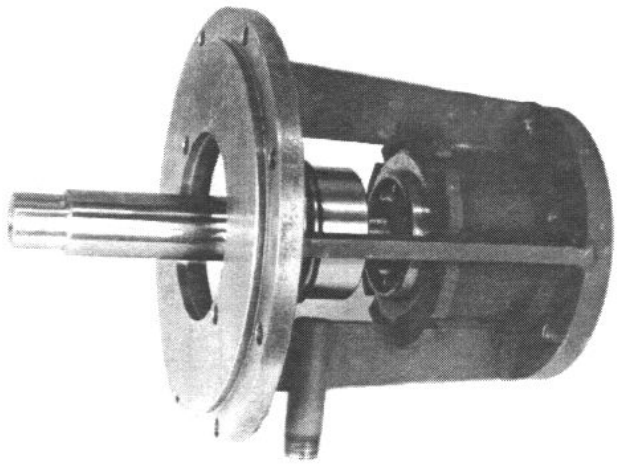


Figure 3-26

FIGURE 3-27 shows the shaft, bearings and bearing cap in place.

Install the stuffing box and align the lubricating hole with grease fittings in the pump frame as shown in FIGURE 3-28.

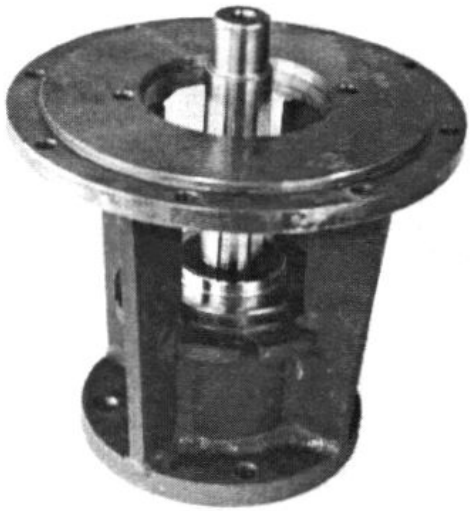


Figure 3-27

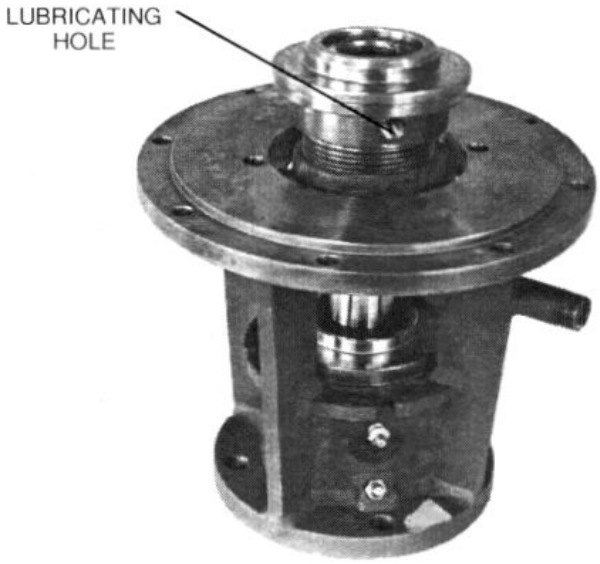


Figure 3-28

Figure 3-29

Install bearing retainer bars and bolts as shown in FIGURE 3-29.

Reassemble the locking assembly and tighten the cap. See FIGURE 3-30.

FIGURE 3-31 and FIGURE 3-32 show front and rear wear plates.

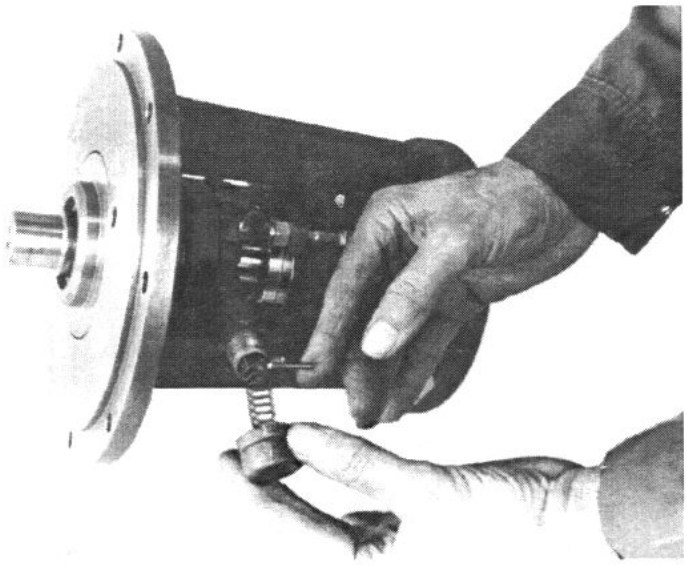
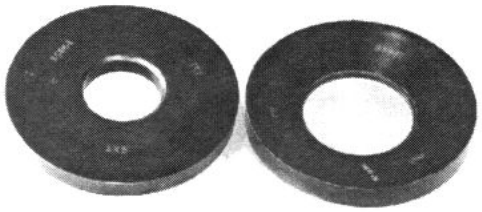


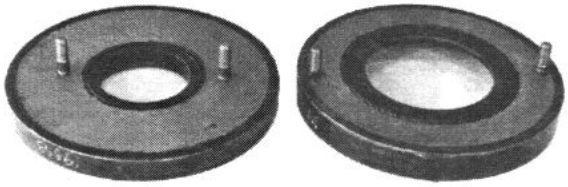
Figure 3-20



REAR WEAR PLATE (RUBBER)

FRONT WEAR PLATE (RUBBER)

Figure 3-31



REAR WEAR PLATE (RUBBER)

FRONT WEAR PLATE (RUBBER)

Figure 3-32

Install the plate and tighten the two (2) retaining nuts only hand tight at this time. This allows the wear plate to center when the rotating assembly is inserted into the volute. See FIGURE 3-33.

Install the key, impeller, lock and cap screw at this time. Torque to values shown below. Install set screw. Refer to FIGURE 3-34.

	LB. FT.	N • M
4 x 5	75 ± 10	100 ± 15
5 x 6	150 ± 20	200 ± 25

Refer to FIGURE 3-25. If the volute and suction adaptor have been removed from the unit, assemble the front wear plate to the suction adaptor as shown above. Tighten the two retaining nuts only hand tight. This allows the wear plate to center when inserted into the volute. If only the rotating assembly has been removed, turn to page 34.

Install the front wear plate and suction adaptor. Tighten all nuts that secure the adaptor to the volute. Tighten the two wear plate attaching nuts last. Refer to FIGURE 3-36.

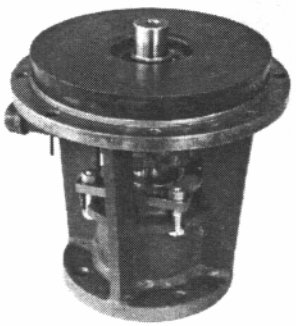


Figure 3-33

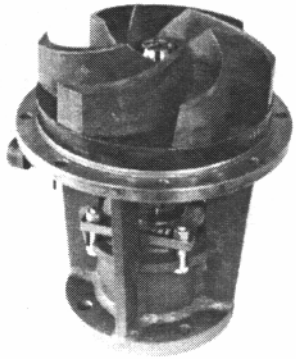


Figure 3-34

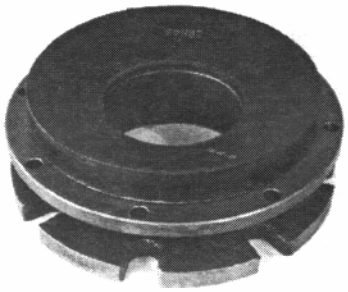


Figure 3-35

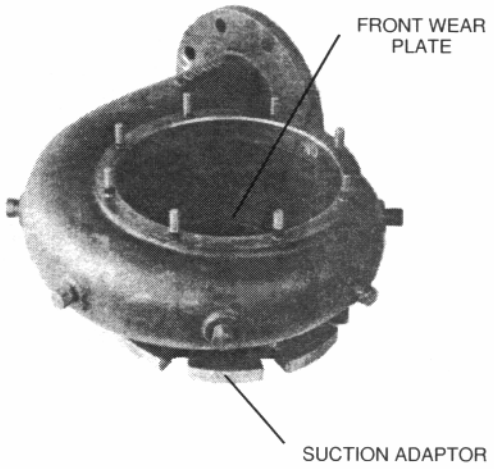


Figure 3-36

In the volute and suctions adaptor have been removed from the unit, assemble as shown in FIGURE 3-37.

If only the rotating assembly and front wear plate have been removed, firtst install the front wear plate and tighten the two attaching nuts. Then assemble as shown in FIGURE 3-37.

After the pump rotating assembly is installed, tighten all the attaching nuts at this time. The remaining two (2) rear wear plate nuts must always be tightened last so that the wear plate will be centered. See FIGURE 3-38.

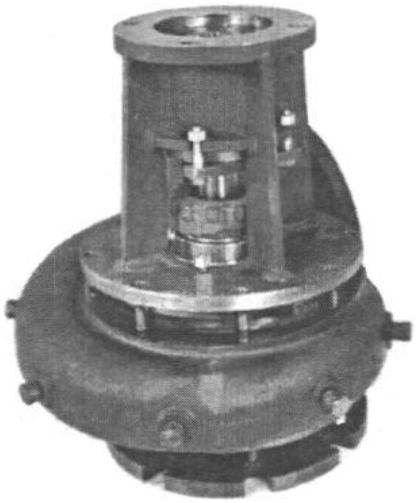


Figure 3-37

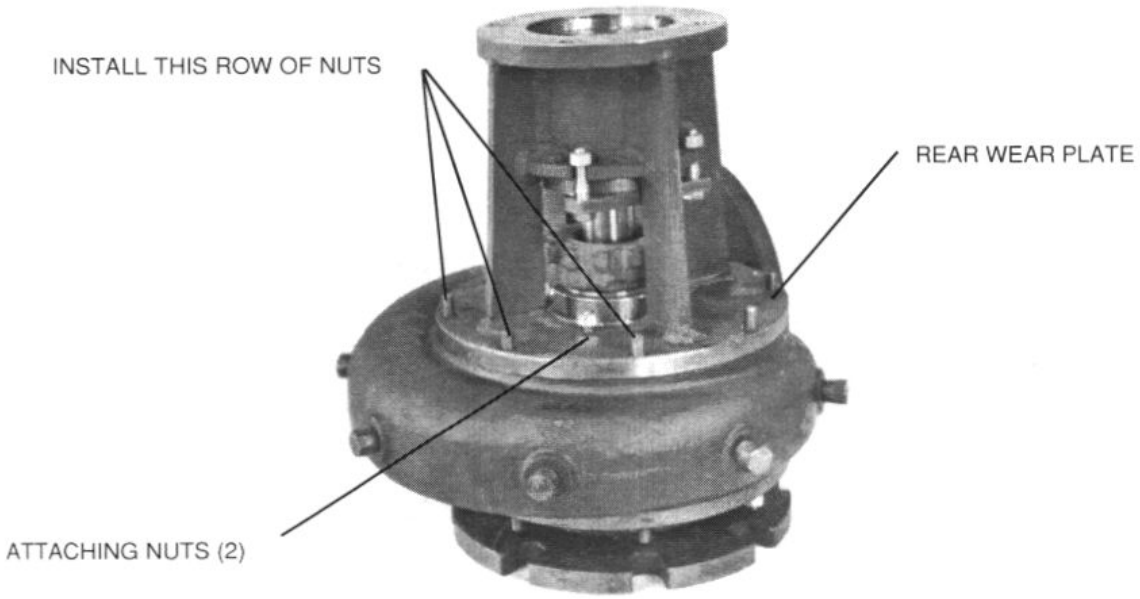


Figure 3-38

If the entire pump has been removed from the unit, headspace between the impeller and front wear plate can be set at this time. See FIGURE 3-39. Use a shim or s0ome flat object 1/16" thick (1.588mm), insert between the impeller and the front wear plate. Add or delete shims as shown in FIGURE 3-40 until this distance of 1/16" is maintained with the front bearing retainer in place and both retaining bars tight.

If the volute and suction adaptor are on the unit, loosen the front bearing retainer cross bars and push the shaft forward until the impeller engages the front wear plate. Pull or pry the shaft and impeller back 1/16" (1.588mm), add necessary shims to maintain this distance. Install and tighten the cross bars.
Check the shaft for free rotation at this time.

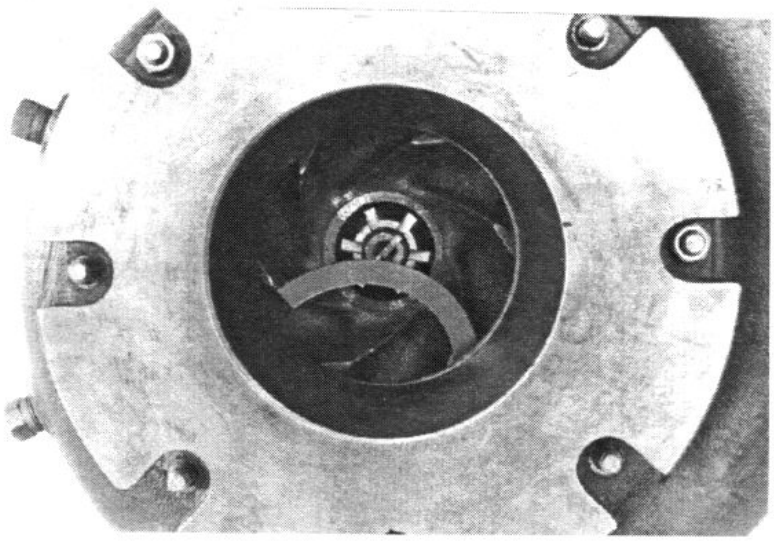


Figure 3-39

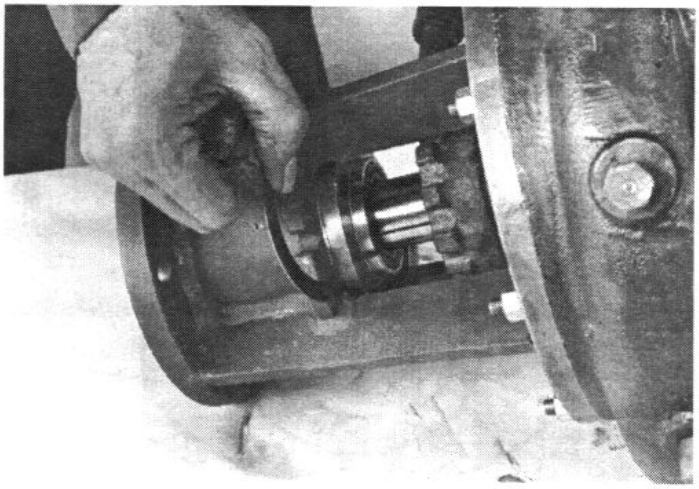


Figure 3-40

FIGURE 3-41 shows the front view of the steel wear plates and O-rings for the 4” x 5” and 5” x 6” pumps.

FIGURE 3-42 shows the front view of the steel wear plates and O-rings for the 4” x 5” and 5” x 6” pumps.

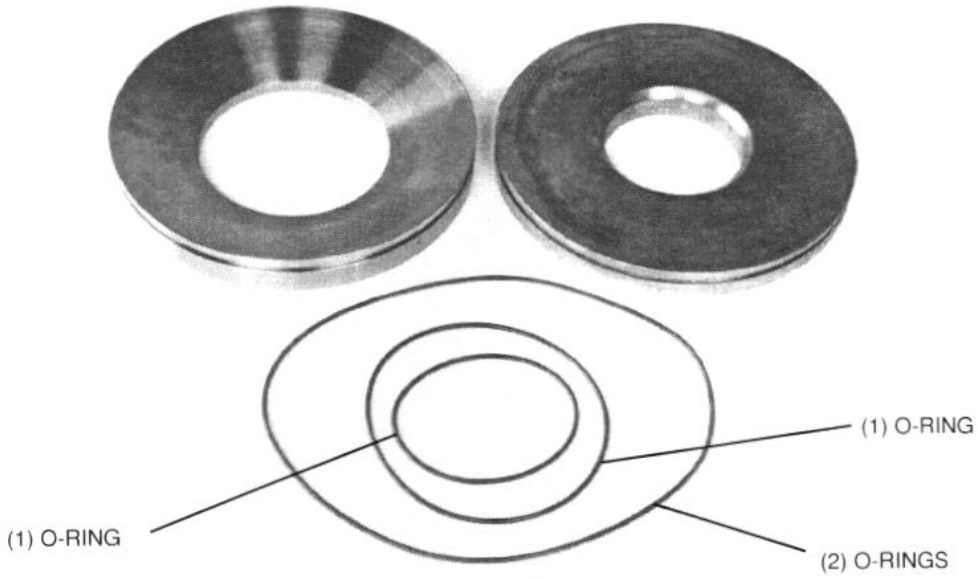


Figure 3-41

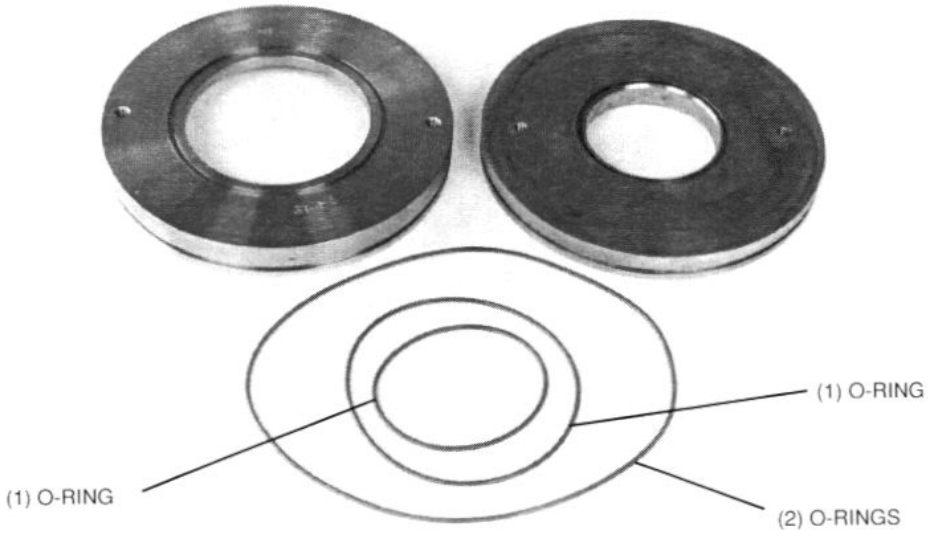


Figure 3-42

FIGURE 3-43 shows additional parts needed for extended shaft models of the 4 x 5 and 5 x 6 pumps.

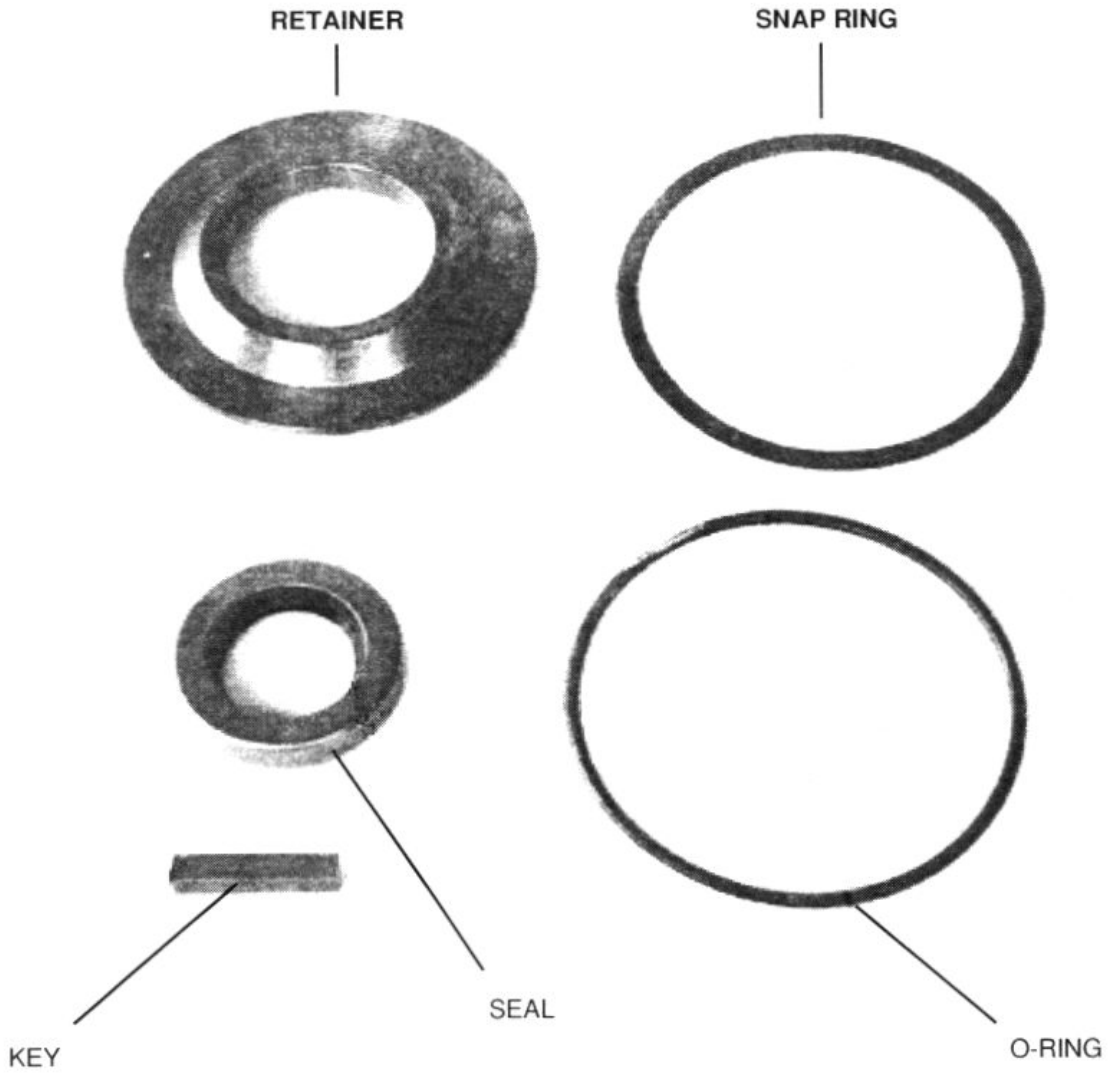
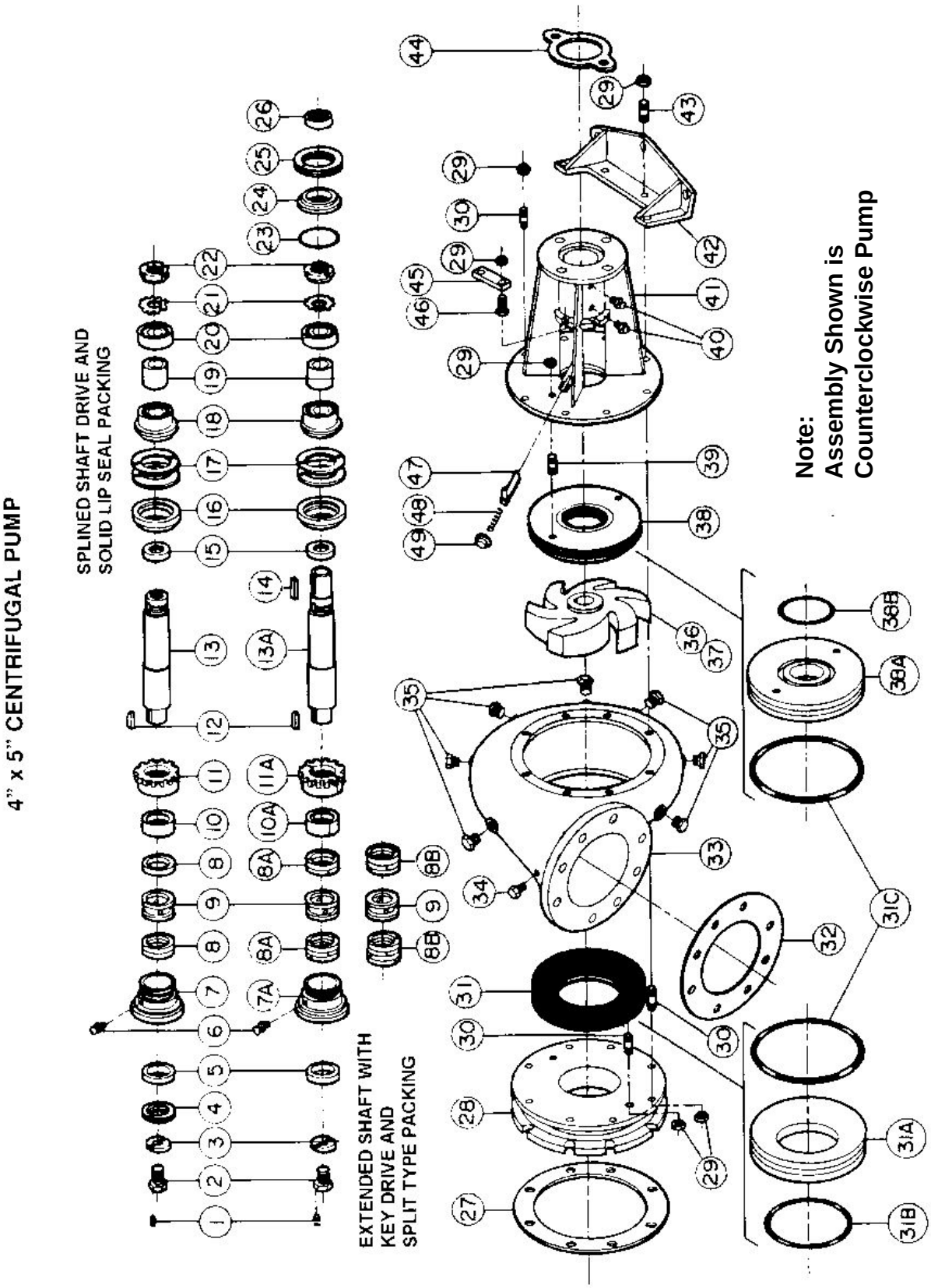


Figure 3-43

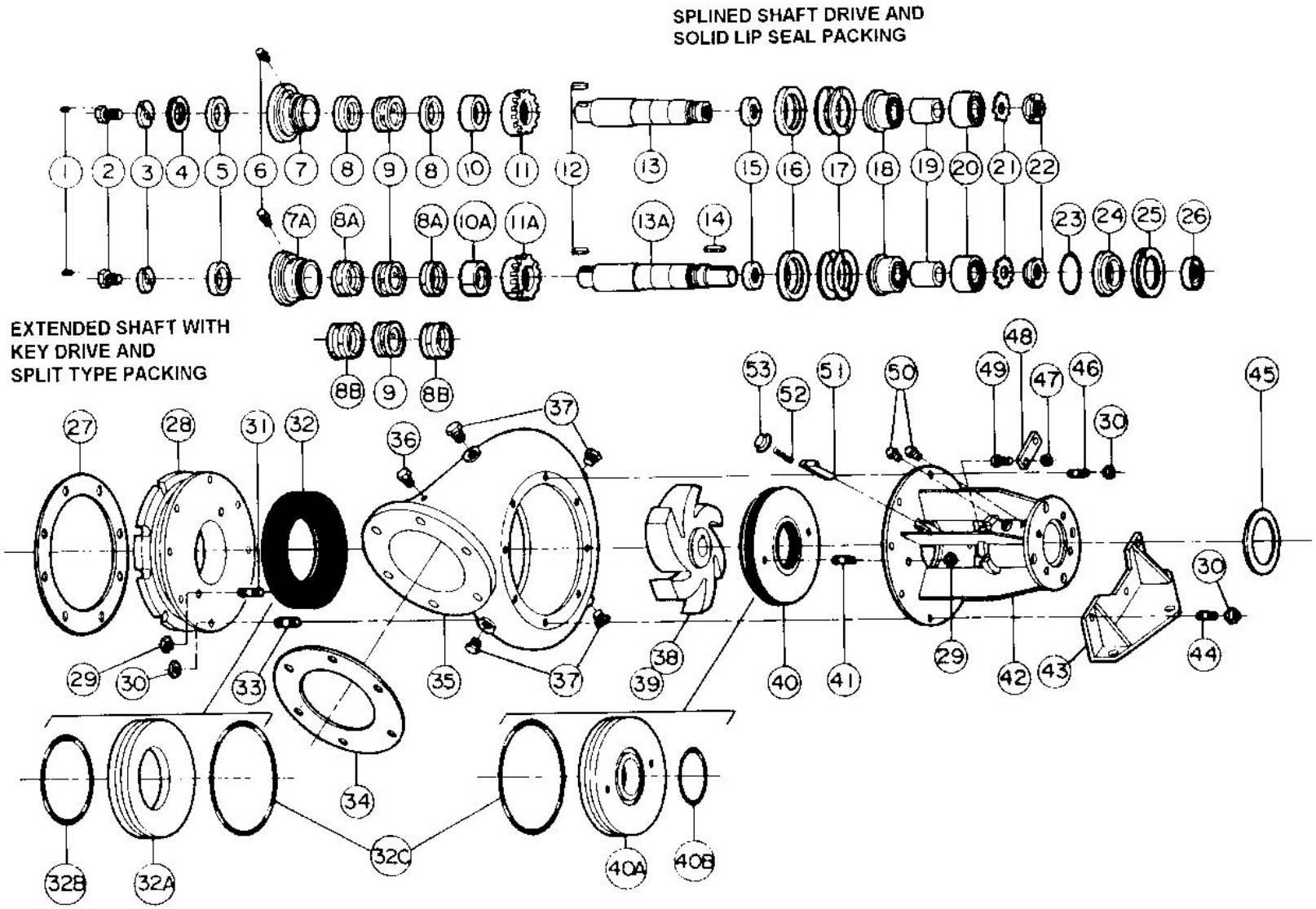

4" x 5" CENTRIFUGAL PUMP
SPLINED SHAFT DRIVE AND
SOLID LIP SEAL PACKING
EXTENDED SHAFT WITH
KEY DRIVE AND
SPLIT TYPE PACKING
Note:
Assembly Shown is
Counterclockwise Pump

Order by Part number and Description. Reference Number for your convenience only.

4" x 5" CENTRIFUGAL PUMP

Ref. No.	Name of Part	Qty.	Part No.
1	SET SCREW	1	28775
2	IMPELLER BOLT	1	19846-T
3	IMPELLER LOCK	1	19843-T
4	SNAP RING	1	26019
5	THROAT BUSHING	1	20123
6	GREASE FITTING	1	45010
7	Not Offered (Replaced with 7A)		
7A	STUFFING BOX (Split Packing)	1	19842-T
8	OIL SEAL SOLID PACKING	3 or 4	6679
9A	SQUARE COMPRESSION PACKAGE (5 pieces per set)	1 Set	26018
9	LANTERN GLAND	1	19850
10	PACKING FOLLOWER, SOLID	1	19845
10A	PACKING FOLLOWER, 2 PIECE	1	19845-2P
11	STUFFING BOX NUT, SOLID	1	19848
11A	STUFFING BOX NUT, 2 Piece	1	19848-2P
12	IMPELLER KEY	1	45002
13	IMPELLER SHAFT, SPLINED	1	19839
13A	IMPELLER SHAFT, EXTENDED KEY DRIVE	1	29132
14	DRIVE KEY	1	45348
15	OIL SEAL, INBOARD	1	15004
16	FRAME CAP	1	Tul19854
17	SHIM	2	19847
18	BEARING, INBOARD DOUBLE ROW	1	45307
19	BEARING SPACER	1	19844
20	BEARING, OUTBOARD SINGLE ROW	1	7607
21	BEARING LOCK WASHER	1	26015
22	BEARING LOCK NUT	1	26014
23	O-RING	1	25AH18
24	OIL SEAL RETAINER, OUTBOARD	1	Tul19852
25	SNAP RING, OUTBOARD	1	26017
26	OIL SEAL, OUTBOARD	1	12456
27	GASKET, SUCTION	1	35193
28	SUCTION ADAPTOR	1	19838
29	NUT	24	39741
30	STUD	14	23244
31	FRONT RUBBER COATED WEAR PLATE	1	Tul19849
31A	FRONT STEEL WEAR PLATE (Requires O-rings)	1	32554
31B	O-RING, for front steel wear plate	1	25BC157
31C	O-RING, for Front/Rear Steel Wear Plates	2	25BC206
32	GASKET DISCHARGE	1	35216
33	VOLUTE	1	19830
34	PIPE PLUG	1	15651
35	PIPE PLUG	7	15653
36	CCW IMPELLER, Counterclockwise (shown)	1	19836
37	CW IMPELLER, Clockwise	1	TUL19835
38	REAR RUBBER COATED WEAR PLATE	1	19853
38A	REAR STEEL WEAR PLATE (Requires O-Rings)	1	32553
38B	O-RING, (For Rear Steel Wear Plate	1	25BC583
39	STUD, REAR STEEL WEAR PLATE	2	23245
40	GREASE FITTING, (One vented)	1 Set	38140
41	FRAME	1	19809
42	MOUNTING BRACKET	1	29141
43	STUD, MOUNTING BRACKET/FRAME/VOLUTE	4	23242
44	GASKET, HYDRAULIC MOTOR/FRAME	1	15286
45	STRAP	2	19855
46	HEX BOLT, STRAP/FRAME	4	655ED080
47	LATCH (Stuffing Box Cap)	1	Tul19498
48	SPRING	1	23868
49	PIPE CAP	1	23015

5" x 6" CENTRIFUGAL PUMP



NOTE: Assembly shown is Counterclockwise Pump

Order by Part number and Description. Reference Number for your convenience only.

5" x 6" CENTRIFUGAL PUMP

Ref. No.	Name of Part	Qty.	Part No.
1	SET SCREW	1	28775
2	IMPELLER BOLT	1	18829-T
3	IMPELLER LOCK		18838-T
4	SNAP RING	1	23144
5	THROAT BUSHING	1	Tul20122
6	GREASE FITTING	1	45010
7	Not Offered (Replaced with 7A)		
7A	STUFFING BOX (Split Packing)	1	18835-T
8	OIL SEAL SOLID PACKING	3 or 4	11551
8A	SQUARE COMPRESSION PACKAGE (5 pieces per set)	1 Set	23541
9	LANTERN GLAND	1	18828
10	PACKING FOLLOWER, SOLID	1	Tul18830
10A	PACKING FOLLOWER, 2 PIECE	1	18830-2P
11	STUFFING BOX NUT, SOLID	1	18837
11A	STUFFING BOX NUT, 2 Piece	1	18837-2P
12	IMPELLER KEY	1	25161
13	IMPELLER SHAFT, SPLINED	1	18826
13A	IMPELLER SHAFT, EXTENDED KEY DRIVE	1	18825
14	DRIVE KEY	1	45116
15	OIL SEAL, INBOARD	1	20098
16	FRAME CAP	1	18821
17	SHIM	2	18832
18	BEARING, INBOARD DOUBLE ROW	1	45309
19	BEARING SPACER	1	18831
20	BEARING, OUTBOARD SINGLE ROW	1	5609
21	BEARING LOCK WASHER	1	23136
22	BEARING LOCK NUT	1	89702
23	O-RING	1	25AH26
24	OIL SEAL RETAINER, OUTBOARD	1	18833
25	SNAP RING, OUTBOARD	1	23145
26	OIL SEAL, OUTBOARD	1	16117
27	GASKET, SUCTION	1	35264
28	SUCTION ADAPTOR	1	Tul18820
29	NUT	4	39741
30	NUT	16	23260
31	STUD, FRONT WEAR PLATE/SUCTION ADAPTOR	2	23244
32	FRONT RUBBER COATED WEAR PLATE	1	18822
32A	FRONT STEEL WEAR PLATE (Requires O-Rings)	1	34018
32B	O-RING, for front steel wear plate	1	25BC205
32C	O-RING, for front/rear steel Wear Plates	2	25BC423
33	STUD SUCTION ADAPTOR/VOLUTE	8	Tul21904
34	GASKET DISCHARGE	1	Tul35194
35	VOLUTE	1	18814
36	PIPE PLUG	1	15651
37	PIPE PLUG	4	15653
38	CCW IMPELLER, Counterclockwise (shown)	1	18824
39	CW IMPELLER, Clockwise	1	18823
40	REAR RUBBER COATED Wear Plate	1	18836
40A	REAR STEEL WEAR PLATE (Requires O-Rings)	1	34017
40B	O-RING, (For Rear Steel Wear Plate)	1	25BC347
41	STUD, REAR STEEL WEAR PLATE FRAME	2	23245
42	FRAME	1	18810
43	MOUNTING BRACKET	1	Tul29358
44	STUD, MOUNTING BRACKET/FRAME/VOLUTE	3	Tul23248
45	GASKET, HYDRAULIC Motor/Frame	1	23494
46	STUD, VOLUTE/FRAME	5	23246
47	LOCKNUT	4	441807000
48	STRAP	2	18855
49	BOLT, STRAP/FRAME	4	45115
50	GREASE FITTING, (One vented)	1 Set	38140
51	LATCH (For Stuffing Box Cap)	1	Tul19498
52	SPRING	1	23868
53	PIPE CAP	1	23015

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